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JOURNAL OF PALEONTOLOGY

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VOLUME 25 SEPTEMBER, 1951 NUMBER 5

THIN SECTIONS OF PALEOZOIC OSTRACODA AND THEIR BEARING ON TAXONOMY AND MORPHOLOGY

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ABSTRACT—The study of thin sections of Paleozoic and Tertiary ostracodes reveals that some forms possess shells of many layers, in contrast to the one-layer shell of most fossil ostracodes. Both the genus *Eridoconcha* and the new genus *Cryptophyllus* exhibit a many-layered shell which appears to be formed by the retention of molts. It is proposed that the cohesion of these molts is not dependent on the shape of the carapace but is a specialized adaptation of generic importance. The genera *Eridoconcha* and *Cryptophyllus* are included in the family Primitiidae. The genera *Leperditia* and *Isochilina*, in thin section, reveal a layer of shell internal to the primary layer which commonly is restricted to the dorsal and ventral margins of the valve. The significance of the secondary layer can not be definitely established at present.

INTRODUCTION

SPECIES of many Paleozoic and Tertiary genera of ostracodes were sectioned to determine whether this technique would aid in problems of ostracode taxonomy and morphology. A partial list of genera sectioned includes: *Ulrichia, Primitiopsis, Milleratia, Eridoconcha, Hollinella, Aechmina, Roundyella, Leperditia, Isochilina, Ankumia, Drepanella, Bollia, Tetradella, Bairdia, Paraparchites, Brachycythere, Cytheropteron* and *Cytheris.*

ACKNOWLEDGEMENTS

I wish to thank Dr. Maynard P. White for suggesting the possibilities of thin sections in studying fossil Ostracoda. Throughout the course of the investigation, Mrs. Betty Kellett Nadeau offered many helpful suggestions and aided greatly in the organization of the manuscript. Professor William Shideler kindly loaned the author several specimens from the Richmond group for comparison, in addition to contributing the holotype of the new species *Cryptophyllus sulcatus*. I also want to thank Mr. John Etter for accompanying the author in the field and helping in the collection of the specimens and Drs. F. Swain and E. Triebel for offering helpful suggestions.

TECHNIQUE

A description of the sectioning technique developed while studying the shell structure of these minute crustaceans has been previously published (Levinson, 1950A). Since the publication of this paper the author has tried many types of dyes and stains in an attempt to bring out details of shell structure. Heeger's potassium ferricyanide-hydrochloric acid treatment (Weller, Henbest and Dunbar, 1942) proved to be the most successful. Care must be exercised

when working with very thin sections to prevent the acid from damaging the specimen.

TYPICAL FOSSIL OSTRACODE SHELL STRUCTURE

The majority of the ostracodes studied, in thin section, exhibit only one distinct layer of shell (pl. 77, figs. 1–4). In sections of double valves the shell interior is either filled with matrix or, as in many Tertiary forms, a cavity. In forms that possess extensions of the shell in the form of such ornamentation as ridges, frills or spines, the shell is indented at the inner surface of the shell where they appear; and a darkened area is commonly developed which bisects this extension of the shell (pl. 77, fig. 2). It appears that such ornamentation was produced in the living animal by a folding of the mantle-like material with later calcification.

THIN SECTIONS OF LEPERDITIIDAE

Species belonging to the family Leperditiidae were sectioned and in all cases revealed that the shell is characteristically composed of two layers, a third layer being present on only one specimen (pl. 77, fig. 5a, b). Specimens yielding excellent sections include: *Eoleperditia ? appressa* (Ulrich) [*Leperditia a.*], *Eoleperditia ? tumidula* (Ulrich) [*Leperditia t.*], *Isochilina armata* (Walcott) and *Teichochilina jonesi* (Wetherby) [*Isochilina j.*].[1] One layer of shell (p) comprises the external expression of the valve and is present the entire length of the shell. A secondary layer (k) is internal to the primary layer with a prismatic structure at right angles to the surface of the valve. On only a few specimens is layer (k) present the entire length of the shell, on most specimens it is restricted to the dorsal and ventral margins, each portion having a length of about one-eighth the height of the valve and decreasing in thickness from the marginal areas until it disappears. When (k) is restricted to the marginal area, there is a decrease in the thickness of (p) at the marginal area with a corresponding increase in the thickness of (p) as the thickness of (k) decreases. This shell structure was found on all leperditids sectioned. On one specimen of *Eoleperditia ? appressa* a third layer of shell is present. It is external to the primary layer and restricted to the dorsal portion of the shell.

It is difficult to explain the significance of the secondary layers found in these forms, for any explanation offered has serious weakness. The secondary layers may be the expression of the inner and outer chitinous layers present in recent forms, but this does not satisfy their consistent restriction to the dorsal and ventral margins on many specimens. Another explanation may be that we have here the beginning of an inner marginal area and reinforced hinge area. This too is highly speculative. A third possibility is that the Leperditiidae are not Ostracoda, as we know them today, but rather an early specialized branch.

MILLERATIA AND *ERIDOCONCHA*

Many forms in the Richmond group have certain characteristics in common that make interpetation of their taxonomic position difficult (pl. 77, figs. 1, 6, 7, 8). They all possess two dorsal swellings on each side of a dorsal sulcus with the posterior swelling larger and higher than the anterior; in addition, one or more concentric ridges or bands are usually present which parallel the free margins of the valve.

When thin sections were made of the series, it was noted that some forms possessed more than one layer of shell, and it was further noted that in these forms the number of external ridges on the specimen has a definite relationship to the number of shell layers (pl. 77, fig. 7a–c). A closer examination, as shown in the following chart, revealed that we were dealing with three distinct forms representing three genera: *Milleratia, Eridoconcha* and the new genus *Cryptophyllus.*

The genus *Milleratia* consists typically of one layer of shell. The shell may be smooth or possess a ridge restricted to the venter and lying a short distance from the ventral portion of the shell. The new genus *Cryptophyllus* has one or more flat ridges which represent one or more overlapping layers of shell. The marginal portion of each layer is expanded to form a flat ridge which borders the free margins of the valve; if more than one ridge is present, they are

[1] See Swartz, 1949, for revision of the Leperditiidae.

separated from each other by a narrow V-shaped groove. The genus *Eridoconcha* has one or more narrow ridges which also correspond to one or more overlapping layers of shell; but in this genus the ridges always lie a short distance from the free margins, and if more than one ridge is present they are separated from one another by a U-shaped trough.

	Milleratia	*Cryptophyllus*	*Eridoconcha*
Number of external ridges	Absent or 1 ridge present only at venter	1 or more flat ridges	1 or more narrow ridges
Position of most ventral ridge	Short distance from free margins	Ventral portion forms free margins	Short distance from free margins
Number of layers of shell	One	One or more	One or more
Spacing between ridges		V-shaped narrow groove	U-shaped trough
Length of sulcus	Slightly less than ½ height of valve	Absent or short	Short to ½ height of valve

The multiple layers of *Eridoconcha* and *Cryptophyllus* are interpreted as being due to incomplete shedding of molts accompanied by later cementation.[2] Measurements of heights of the individual molts (text-fig. 1) show that there is a correlation of the molts from one individual to another and that the difference in size and the number of ridges of an individual are dependent upon which molts are retained by the individual. A larger number of ridges does not imply the specimen is more mature than an individual with a lesser number of ridges. Within one species, one individual may retain molts of instars #1, #2 and #3, another of instars #3, #4 and #5 and another of instars #5 and #6. It is evident that the last individual, consisting of two ridges, is more mature [has retained later molts] than the first two individuals consisting of three ridges. The retained molts are usually in a consecutive sequence, but individuals have been found in which the sequence has been broken because of the absence of molts. [e.g. an individual may retain only molts of instars #3, #5 and 6 with the molt of instar #4 absent.] The multi-layered shells of the genera *Eridoconcha* and *Cryptophyllus* may be any combination of retained molts.

The question may be raised as to the justification for establishing a genus on the basis of retention of molts. It is a common

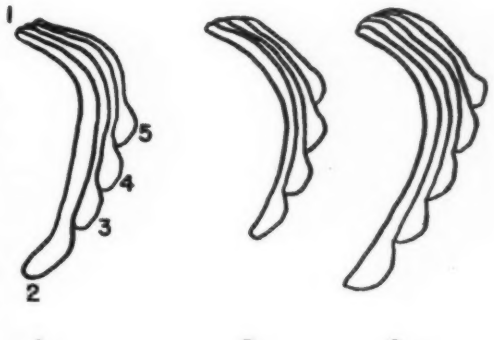

FIG.—*1a*, idealized drawing of section of *Cryptophyllus oboloides*. The heights of the individual layers were measured [e.g. 1 to 2, 1 to 3, etc.] in mm. and placed in the chart figure *1b*.

	1	2	3	4	5	6	7	8	9	10	11
molt 6	.875										.750
molt 5	.687	.625	.725	.625	.625	.625	.650	.625	.625		.625
molt 4	.525	.500	.575	.525	.550	.525	.550	.562	.497	.500	.470
molt 3	.375	.350	.412	.400	.425	.410	.437	.350	.400	.400	.375
molt 2	.225	.225	.275	.275		.300	.312	.310		.300	.300
molt 1	.125		.175			.187				.200	

FIG.—*1b*, chart of heights [in mm.] of individual layers of specimens of *Cryptophyllus oboloides*. The numbers in bottom row refer to numbered specimens. Molt 1 is the smallest "molt" found but does not necessarily assume a relationship with instar #1.

[2] The retention of molts has been independently noted by F. M. Swain and E. J. Bolin of the University of Minnesota, and by R. T. Drake and J. E. Keenan formerly of the University of Missouri.

occurrence throughout the geologic column to find a smaller molt lodged within a larger molt, but only in these two distinct genera do we find a large molt retained consistently within a smaller molt. To achieve this condition from Oil Creek (Lower Ordovician) through Elkhorn (Upper Ordovician) time requires a distinct specialization not yet found in any other ostracode genus or species.

Eridoconcha and *Cryptophyllus* are included in the family Primitiidae because of the presence, in both genera, of a distinct sulcus and a hingement similar to other members of the family; in addition, *Eridoconcha* shows an external resemblance to *Milleratia*, a typical member of this family.

A number of species of these genera, at present, are good index fossils. The two genera occur together only in the Elkhorn (Richmond). *Eridoconcha rugosa* is restricted to the Maysville, *E. multiannulata*, n. sp. is restricted to the Waynesville and *Cryptophyllus sulcatus*, n. sp. is found only in the Elkhorn.

DESCRIPTION OF SPECIES

Order OSTRACODA Latreille, 1802
Superfamily BEYRICHIACEAE Ulrich & Bassler, 1923
Family PRIMITIIDAE Ulrich & Bassler, 1923
Genus ERIDOCONCHA Ulrich & Bassler, 1923

Eridoconcha ULRICH & BASSLER, 1923, Maryland Geol. Surv., Silurian vol., p. 297, fig. 14.

Type Species (by original designation): *Eridoconcha rugosa* Ulrich and Bassler, 1923; Maysville, Cincinnati, Ohio.

Description.—Carapace small, subovate, umbonate with subtriangular inflation or bilobed extension above dorsum, if lobate, posterior swelling larger than anterior, hinge moderately long, straight; cardinal angles equal, venter parallel to hinge, slightly convex, ends broadly rounding to cardinal angles; convexity of surface increases from marginal area to dorsal umbo, greatest thickness at umbo; dorsal sulcus short or elongate; one or more narrow, concentric ridges par-

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EXPLANATION OF PLATE 77

FIGS. *1a–d*—*Milleratia cincinnatiensis* (Miller). *1a*, right valve, female; *1b*, section of double valve, female, through posterior swelling, polarized light, unretouched; *1c*, same as *1b* except retouched; *1d*, right valve, male. Waynesville. All ×40. (p. 559)

2a–c—*Milleratia shideleri* Levinson, n. sp. *2a*, left valve, female, ×40; *2b*, section of double valve, female, through posterior swelling, polarized light, unretouched, ×28; *2c*, same as *2b* except retouched. Elkhorn. (p. 559)

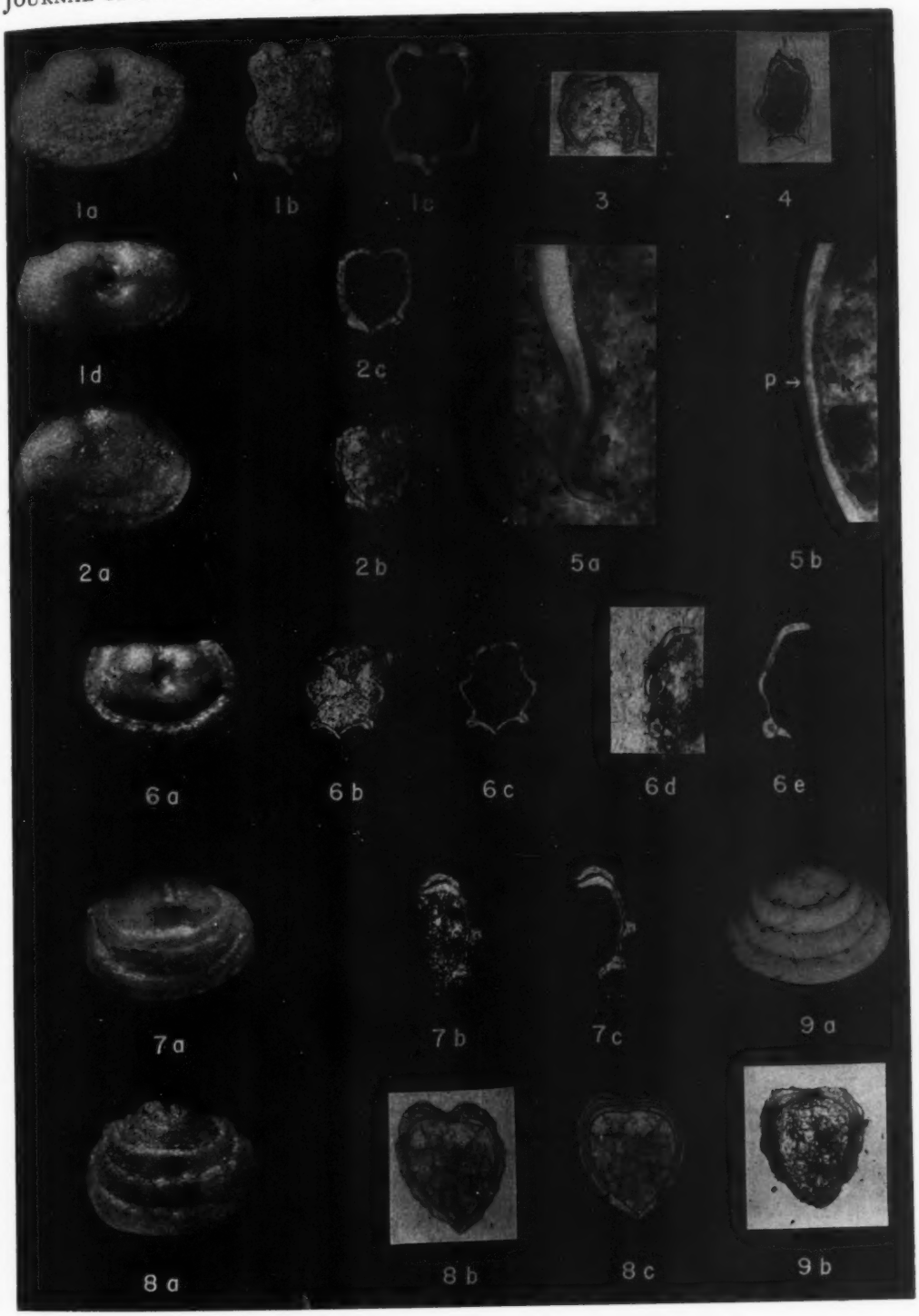
3, 4—*Hollinella* sp., sections through double valves showing the one layer of shell typical of most ostracodes, transmitted light. Francis formation, Ada, Oklahoma. *3*, ×40; *4*, ×33. (p. 554)

5a, b—*Teichochilina jonesi* (Wetherby). *5a*, section of left valve, ventral portion showing layer *k* restricted to margin. *5b*, section of left valve, median portion showing layer *k* present from the dorsum to the venter, transmitted light, ×10. (p. 554)

6a–e, 7a–c—*Eridoconcha multiannulata* Levinson, n. sp. *6a*, right valve, one-ridged form, female; *6b*, section of double valve, female, through sulcus, polarized light, unretouched; *6c*, same as *6b* except retouched showing one layer of shell; *6d*, section of double valve, female, through posterior swelling, transmitted light, unretouched; *6e*, same as *6d* except retouched showing one layer of shell. *7a*, right valve, two ridged form, holotype, female; *7b*, section of double valve, female, through posterior swelling, polarized light, unretouched; *7c*, same as *7b* except retouched showing two layers of shell [note U-shaped trough between ridges]. Waynesville. All ×40. (p. 557)

8a–c—*Cryptophyllus sulcatus* Levinson, n. sp. *8a*, right valve, female; *8b*, section of double valve through posterior swelling, transmitted light, unretouched; *8c*, same as *8b* except retouched showing four layers of shell and V-shaped groove between ridges. Elkhorn. All ×40. (p. 558)

9a, b—*Cryptophyllus oboloides* (Ulrich & Bassler). *9a*, side view; *9b*, section through double valve at umbo, transmitted light, unretouched. Bromide formation, Fitts Pool, Oklahoma. All ×30. [fig. 9a, photo by Triebel]. (p. 558)



Levinson, Paleozoic ostracode morphology

allel the lower margins, the most ventral of the ridges always lies a short distance from the ventral margin, if more than one ridge present, they converge at dorsum, ridges separated from one another by a U-shaped trough. Carapace equivalved. Hingement unknown. (Hingement described as that of *Eridoconcha* [Levinson, 1950B, p. 68, fig. 5] should be referred to the new genus *Cryptophyllus*.) Dimorphism present in some species, males more elongate than females.

Eridoconcha is one of the two known genera in which molts may be retained. One ridge a short distance from the ventral margin is present on each individual molt; additional ridges, if present, are retentions of molts of younger instars; the number of ridges correspond to the number of molts retained. The number of ridges present is not a criterion of the maturity of the specimen as explained above.

Occurrence.—Upper Ordovician, Maysville to Richmond (Waynesville), Ohio and Indiana.

Remarks.—This genus is placed in the family Primitiidae because of the presence of a definite sulcus and its external resemblance to *Milleratia* Swartz, a typical member of this family. The genus *Eridoconcha* now consists of only the two species, *E. rugosa* [the type species] and *E. multiannulata* n. sp. The species *E. simpsoni* Harris, *E. materni* Bassler and Kellett, *E. magnus* Harris, *E. concentrica* Coryell and Williamson and *E. oboloides* Ulrich and Bassler are referred to the new genus *Cryptophyllus*. *E. rotunda* Ulrich and Bassler from the Middle Silurian of Maryland was described as an altogether peculiar form with irregular concentric rows of punctae doubtfully referable to *Eridoconcha*. This species is not a member of either of the above genera and its taxonomic position is uncertain.

The genus *Conchoprimitia* Öpik differs from *Eridoconcha* and *Cryptophyllus* in the length of the hinge line. In the original description of the genus Öpik (1935) remarks "Small Primitiidae with straight hinge line, with one or two pairs of bands . . . *Eridoconcha* Ulrich and Bassler has the concentric grooves also, but differs in having a short hinge."

The absence of a dorsal ridge encircling the umbo in the single molt form of *Eridoconcha* differentiates it from species of *Jonesites* Coryell.

The evolution in this group is toward a decrease in the number of concentric ridges or retained molts, with a corresponding increase in the number of specimens consisting of only one and two molts. From Maysville through Richmond there appears a gradual loss in the ability to retain molts. In the Maysville it is not uncommon to find specimens with four or more molts, whereas in the Richmond a form with more than two retained molts is rare.

ERIDOCONCHA MULTIANNULATA
Levinson, n. sp.
Plate 77, figures 6,7 a–c

Description.—Carapace small, with pronounced bilobed inflation above the dorsum, the posterior swelling is the larger, hinge moderately long, straight; cardinal angles equal, venter parallel to hinge, slightly curved, ends broadly rounding to cardinal angles; convexity of surface increases from marginal area to bilobed swelling, greatest thickness at posterior swelling. Prominent sulcus slightly less than one-half the height of the valve. One to three concentric, narrow ridges parallel the lower margins, if more than one, the ridges tend to converge at the dorsum, the most ventral of the ridges always lies a short distance from the ventral margin, additional ridges, if present, are separated from one another by a U-shaped trough. Carapace equivalved. Hingement unknown. Dimorphism present, males more elongate than females.

In this species, three ridge form rare, two ridge form common, one ridge form abundant. Number of ridges present dependent on number of retained molts.

Dimensions.—Holotype, single valve, female, length .60 mm., height .40 mm., width .21 mm. (two ridge form). Paratype, single valve, female, length .51 mm., height .31 mm., width .21 mm. (one ridge form). Paratype, double valve, male, length .58 mm., height .31 mm., width .29 mm. (one ridge form). Paratype, double valve, female, length .55 mm., height .40 mm., width .40 mm. (three ridge form).

Types.—Holotype USNM 116365; paratypes 116366a-e.

Type locality.—Locality 6b-1; Ohio, Ham-

ilton Quadrangle, SW¼ Sec. 26. T. 5 N., R. 1 E., ½ mile south of Oxford, Ohio, on north bank of Talawanda Creek, 50 yards east of C.I. & W. R.R. trestle.

Occurrence.—Waynesville formation (Richmond) of Ohio.

Remarks.—This species differs from *E. rugosa* in the presence of a bilobed inflation above the dorsum, the posterior swelling of which is wider and higher than the anterior, in addition, in *E. multiannulata* the sulcus is more elongate. Specimens with more than three ridges [which consist of three attached molts] have not been found in the new species, whereas in *E. rugosa* more than three ridges are commonly present.

Genus CRYPTOPHYLLUS Levinson, n. gen.

Type Species: Eridoconcha oboloides Ulrich and Bassler; Decorah (Middle Ordovician) St. Paul, Minnesota.

Description.—Carapace ovate to subquadrate, small to medium size, umbonate, subtriangular inflation or bilobed extension above the dorsum, if lobate, posterior swelling larger and higher than anterior, hinge straight, short to medium length, cardinal angles equal and rounded, venter usually elongate, parallel to hinge and rounding to cardinal angles; convexity of surface increases from marginal area to dorsal umbo, greatest thickness at umbo; short dorsal sulcus may be present; one or more wide concentric ridges parallel lower margins tending to converge at dorsum, the most ventral ridge borders the free margins of the valve; additional ridges, if present, separated from one another by narrow V-shaped grooves. Carapace equivalved. Hingement of left valve consists of a ridge running the length of the dorsal margin; dorsal to the ridge is a prominent groove, ventral to the ridge is a fine groove. Hingement of right valve not observed. The hingement originally described as that of *Eridoconcha* (Levinson, 1950B, p. 68, fig. 5) is now referred to the new genus *Cryptophyllus*. The grooves present at the dorsum may be the spacing between instars. Dimorphism present in some species, males more elongate than females.

Number of ridges present dependent on number of retained molts [see generic description of *Eridoconcha*].

Occurrence.—Oil Creek (Chazy) through Elkhorn (Richmond), Ohio, Indiana, Missouri, Oklahoma and Minnesota; Upper Devonian, Belgium; Middle Silurian, Indiana.

Remarks.—The following species are included in the genus *Cryptophyllus:*

Cryptophyllus oboloides (Ulrich and Bassler) = *Eridoconcha oboloides* Ulrich and Bassler [Decorah, St. Paul, Minn.]
Cryptophyllus simpsoni (Harris) = *Eridoconcha simpsoni* Harris [Bromide, Okla.]
Cryptophyllus concentricus (Coryell and Williamson) = *Eridoconcha concentrica* Coryell and Williamson [Waldron, Ind.]
Cryptophyllus materni (Bassler and Kellett) = *Eridoconcha materni* Bassler and Kellett [U. Devonian, Belgium]
Cryptophyllus magnus (Harris) = *Eridoconcha magnus* Harris [Oil Creek, Okla.]
Cryptophyllus sulcatus Levinson n. sp. [Elkhorn, Ind., Ohio]

This genus is placed in the family Primitiidae because of the presence of a distinct sulcus in some species and a bilobed inflation and hingement similar to *Milleratia*, a typical member of this family.

Drake (1940) has noted a relationship between the single molt form of *Eridoconcha* and *Schmidtella*. The absence of ventral overlap and the presence of a marginal ridge [which may appear externally as a slight inflation] distinguishes the single molt form of *Eridoconcha* from the probably related species of the genus *Schmidtella*.

The evolutionary tendency in this group is toward a decrease in size from a maximum of 1.9 mm. in the Oil Creek to 0.6 mm. in the Richmond. There is, in addition, a decrease in the number of concentric ridges or molts retained from a maximum of 11 in the Oil Creek to five in the Richmond.

CRYPTOPHYLLUS SULCATUS Levinson, n. sp.

Plate 77, figure 8 a–c

Description.—Carapace small, subquadrate, umbonate with subtriangular bilobed inflation above dorsum, posterior swelling larger and higher than anterior, hinge straight, short, cardinal angles equal and rounded, venter elongate, parallel to dorsal margin, rounding to cardinal angles, great-

est thickness at umbo; short dorsal sulcus; one or more wide concentric ridges parallel lower margins tending to converge at dorsum, the most ventral ridge borders free margin, additional ridges, if present, separated from one another by narrow V-shaped grooves. Carapace equivalved. Hingement as under generic description. Dimorphism present, presumed males more elongate than females.

Dimensions.—Holotype, double valve, female, length .60 mm., height .44 mm., width .36 mm. Paratype, double valve, male, length .55 mm., height .36 mm., width .34 mm.

Types.—Holotype, USNM 116362; paratypes, 116363 a, b.

Type locality.—Locality 10-1; an exposure now nearly grassed over on the east side, south end of the C. and O. R.R. trestle over Short Creek, about three miles south of Richmond, Indiana. Basal Elkhorn. This species is also found at locality 11-1 (see below).

Occurrence.—Elkhorn formation (Richmond) of Indiana and Ohio.

Remarks.—In this species, the one, four and five ridge forms are rare, the two and three ridge forms abundant. *Cryptophyllus sulcatus* is distinguished by the prominent subtriangular bilobed inflation extending beyond the hinge margin.

Genus MILLERATIA Swartz, 1936

Milleratia SWARTZ, 1936, Jour. Paleontology, vol. 10, p. 568, pl. 86, figs. 7a–c.

Type Species (by original designation): *Beyrichia cincinnatiensis* Miller; top of Lorraine, Ohio; Arnheim and Waynesville of Ohio, Indiana and Michigan.

Description.—Carapace small, subovoid, anterior more narrowly rounded, posterior often with "forward swing"; hinge long, straight; anterior cardinal angle more obtuse and rounded; a dorsal swelling is separated into two lobes by a dorsal sulcus, the posterior swelling larger and higher, a thin or a strong deep dorsal sulcus extends to nearly one-half the height of the valve, a pit developed at ventral end; greatest thickness behind middle, greatest height at posterior swelling; a ridge may be present parallel to the ventral margin, it lies a short distance from the margin and becomes obscure as it nears the cardinal angles; free margins of the valves commonly expanded into a narrow flattened border; valves essentially equal, commonly one valve internally beveled to receive ventral portion of opposite valve (pl. 77, fig. 1c), either valve may contain beveling within one species. Surface smooth. Hingement of right valve consists of a prominent ridge along the length of the dorsal margin; ventral to the ridge is a distinct groove. (Levinson, 1950B, fig. 6) No hingement discernible on left valves. Dimorphism present in some species, males more elongate than females.

Range.—Top of Lorraine, Ohio; Arnheim and Waynesville of Ohio, Indiana and Michigan; Elkhorn of Ohio.

Remarks.—The genus *Milleratia* is here expanded to include the closely related species *M. shideleri* here described.

MILLERATIA SHIDELERI Levinson, n. sp.
Plate 77, figure 2 a–c

Description.—Carapace small, subovoid, anterior more narrowly rounded, posterior with slight "forward swing," anterior cardinal angle more rounded, venter slightly rounded and parallel to dorsal margin; a dorsal swelling is separated into two lobes by a thin dorsal sulcus, the posterior swelling is larger and higher than the anterior, the anterior sometimes weakly developed; dorsal sulcus extends to slightly less than one-half height of valve, a pit prominent at ventral end; greatest thickness behind middle, greatest height at posterior swelling; a ridge is present parallel to the ventral margin, it lies a short distance from the margin and becomes obscure as it nears the cardinal angles; free margins of the valves slightly expanded into a flattened border; valves appear equal; surface smooth. Hingement not observed. Dimorphism unknown.

Dimensions.—Holotype, left valve, length .65 mm., height .44 mm., width .19 mm.

Type.—Holotype, USNM 116364.

Type Locality.—Locality 11-1; Ohio, College Corner Quadrangle SW. ¼ sec. 4. T. 6 N., R. 1 E., ¼ mile north of Fairhaven, Ohio, an exposure on the east bank of Fourmile Creek.

Occurrence.—Elkhorn formation (Richmond) of Ohio.

Remarks.—This species can be differentiated from *M. cincinnatiensis* by the presence of a ridge near the ventral portion of the shell, in addition, in this species the sulcus is thin and shorter than the type species and the dorsal swellings not as highly inflated. .

Single valves of *M. shideleri* are common but double valves are very rare.

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OSTRACODES FROM THE MAQUOKETA SHALE OF MISSOURI

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ABSTRACT—Fifteen genera of ostracodes including 28 species, 19 of the species new, are figured and described. This assemblage compares about as closely with that of the Eden, the Maysville, and the Richmond groups of the Ohio valley as it does with the Maquoketa assemblage from Iowa, described by R. C. Spivey, 1939. This is the lowest published stratigraphic occurrence of spinose-frill ornamented species of the genus *Aechmina* which occur in the Wenlock and Ludlow beds, Silurian, of England, and in the Silurian of Gotland. A revision of the genus *Eridoconcha* is proposed.

INTRODUCTION

THE Maquoketa shale is the youngest formation of the Upper Ordovician in the Mississippi valley. Stuart Weller (1907, p. 520) subdivided the Upper Ordovician of southeastern Missouri into two formations, the Richmond proper (now Fernvale) below, and the Maquoketa above.

C. A. White (1870) first applied the name Maquoketa shale to the exposures along the Little Maquoketa River about twelve miles west of Dubuque in eastern Iowa. Here the formation was described recently by H. S. Ladd (1926, p. 330) as consisting of about 190 feet of bluish or greenish shale with a phosphatic conglomerate zone (Depauperate zone) at the base and a calcareous zone (*Cornulites* zone) at the top. Although the shale thins southward into Missouri, its characteristics remain much the same as at the type locality.

Exposures of Maquoketa shale are present in Minnesota, Wisconsin, Iowa, eastern Missouri and western Illinois. H. S. Ladd (1926) stated that the Iowa outcrops are confined almost entirely to an irregular northwest-southeast belt running across the northeastern corner of the state, this belt continuing northward into southern Minnesota, southward into Illinois, and thence northward into Wisconsin. In Missouri the exposures are limited to the eastern margin from near Hannibal to Cape Girardeau.

The best outcrops in southeastern Missouri are near the Mississippi River and extend from Ste. Genevieve County south to Cape Girardeau. These are near the western limit of continuous Maquoketa shale which centers in the Illinois basin and pinches out against the Ozark uplift. Southwest of the Ozark region the Cason shale in northern Arkansas and the Sylvan shale in Oklahoma are correlatives of the Maquoketa.

In eastern Missouri between Hannibal and Ste. Genevieve County outcrops are present along the Mississippi River bluffs and near the mouths of tributary valleys. Maquoketa shale underlies the northeastern corner of the state in a triangular area extending about 50 miles westward from the Mississippi River at the Iowa border and southward as far as the vicinity of St. Louis.

Exposures at Castlewood, Missouri, 18 miles southwest of St. Louis, appear to be near the extreme southern limit of this area of continuous Maquoketa shale. Here the shale rests on Kimmswick limestone and is overlain by a wedge of Grassy Creek shale or by Bushberg sandstone. The Maquoketa is about 18 feet thick, dark gray in color, and has from one to three thin phosphatic conglomerate zones near the top. Most of the ostracodes described here were taken from these zones. One of the zones, three inches thick and three feet below the top of the shale at the west end of the exposure, is much pyritized and contributed most of the best preserved specimens. E. B. Branson (1941) prepared a stratigraphic column and a geologic cross-section showing the beds above and below the Maquoketa shale in the Castlewood region.

Fifteen genera of ostracodes including 28 species, 19 of the species new, are figured and described in the following pages. Only three of these species were reported from the Maquoketa of Iowa by R. C. Spivey (1939) in the only other published article on Maquoketa ostracodes, but at least five additional Iowa species are closely related to

Missouri species. Three species found in the Maquoketa of Missouri also occur in the Eden group near Cincinnati, Ohio. At least three species are also common to the Maysville group of the Ohio valley.

In the Maquoketa shale are the oldest reported spinose-frilled species of the genus *Aechmina*. Spinose-frilled species are known to occur in the Wenlock and Ludlow beds, Silurian, of England, and their presence in the Maquoketa shale may be of value in determining the position of the Ordovician-Silurian boundary in the Mississippi valley area. The correlative value of this group of species depends upon its geologic range which is not well known. If the range is short, the Maquoketa could correlate with type Silurian beds in England. One of the species, *Aechmina cuspidata* Jones and Holl is known to occur in Lower Devonian beds, the New Scotland formation of West Virginia, and in the Haragan formation of Oklahoma.

Dr. E. B. Branson directed the research, checked the descriptions and discussions, offered suggestions pertaining to subject matter, and edited the manuscript. Dr. M. G. Mehl gave technical assistance in isolating and photographing specimens and in making the plates.

Figured specimens and specimens designated as types are in the collections of the Department of Geology, University of Missouri, Columbia, Missouri. A complete set of duplicate specimens was furnished to the United States National Museum, Washington, D. C. The numbers of the specimens are those of the ostracode collections of the University of Missouri and of the National Museum.

SYSTEMATIC DESCRIPTIONS

Order OSTRACODA Latreille

Family APARCHITIDAE Ulrich & Bassler

Genus APARCHITES Jones

APARCHITES TRENTONENSIS Ulrich

Plate 78, figures 29–31

Aparchites minutissimus trentonensis ULRICH, 1894, Minnesota Geol. Nat. Hist. Survey, vol. 3, pt. 2, p. 646, pl. 43, figs. 18–20.
Aparchites trentonensis KAY, 1940, Jour. Paleontology, vol. 14, p. 244, pl. 29, fig. 33.

Outline suboval in lateral view. Both the posterior and the anterior margins evenly semicircular, the posterior much the longer. Dorsal margin straight, ventral margin convex. Test longest slightly above midheight, thickest through the center, highest in the posterior third. Retral swing pronounced. Surface uniformly tumid, unornamented.

Remarks.—The suboval outline with well rounded posterior and anterior margins, and the complete lack of ornamentation distinguish this species. It does not have the thickened border present on most other species of the genus *Aparchites*.

Figured specimens.—UM, 0-983-4, 0-983-5.
Similar specimens.—USNM, 113434.

APARCHITES BARBATUS Keenan, n. sp.

Plate 78, figures 19, 20

Outline suboval in lateral view. Both the anterior and the posterior margins uniformly curved, the posterior more broadly curved. Dorsal margin straight, ventral margin convex, the hinge two-thirds the length of the valve. Valve uniformly tumid. A smooth submarginal flange, parallel with the ventral free edge of the valve, recedes into the valve surface both anterodorsally and posterodorsally at points slightly below midheight. Two short series of inconspicuous spines, one at the anterior end and one at the posterior end of the flange, run parallel with the free edge between the free edge and the submarginal flange. Not more than 12 small spines are present in each short series.

Remarks.—*A. barbatus* most closely resembles *A. carinatus* Kay (1940, p. 244). It does not have the submarginal flange parallel with the entire free margin as does *A. carinatus*, but has a flange only along the ventral margin. The marginal spines of *A. carinatus* are parallel with the entire free margins of the valve while *A. barbatus* has only the two short series of marginal spines, one set at the anterior end and the other set at the posterior end.

Holotype.—UM, 0-982-3.
Paratypes.—UM, 0-979-1, 0-979-2,
Other specimens.—USNM, 113435.

Genus PARASCHMIDTELLA Swartz

PARASCHMIDTELLA IRREGULARIS Keenan, n. sp.

Plate 78, figures 32–34

Outline suboval in lateral view, the hinge straight and about two-thirds the length of

the valve. Both dorsal angles rounded and obtuse, the posterior angle smaller than the anterior one. Valves relatively flat. Except for a narrow smooth margin the surface ornamented with pits, about 25 in number. The pits irregularly spaced but falling into three distinct groups (pl. 78, fig. 34). The circular shape of the pits interrupted by a small pointed projection from the wall into the pit, this projection always extending inward from the side of the pit that is closest to the nearest margin of the valve.

Remarks.—*P. irregularis* differs from other species of the genus *Paraschmidtella* in its peculiar and consistent pattern of spacing of the pits. The pointed projections into the pits are presumably one of the specific characteristics but they may be present and not noticed on specimens of other species having less perfect preservation.

Holotype.—UM, 0-984-3.

Paratypes.—UM, 0-984.

Other specimens.—USNM, 113441.

Family LEPERDITELLIDAE Ulrich & Bassler

Genus LEPERDITELLA Ulrich

LEPERDITELLA DORSICORNIS (Ulrich)

Plate 78, figures 14–16

Leperditia ? (*Primitia*) *dorsicornis* ULRICH, 1892, Am. Geol., vol. 10, p. 267, pl. 9, figs. 24–26.

Leperditella ? *dorsicornis* ULRICH, 1894, Minnesota Geol. Nat. Hist. Survey, vol. 3, pt. 2, p. 639, text figs. 19, 20.

Remarks.—Specimens of this species from the Maquoketa at Castlewood, Missouri are small. The sulcus is not as prominent as on the specimens described by Ulrich but is usually barely perceptible. Only the left valve has the dorsal prominence. The right valve, although smaller than the left, overlaps it along the ventral border (pl. 78, figure 16).

Figured specimens.—UM, 0-981-3, 0-981-4.

Similar specimens.—USNM, 113439.

LEPERDITELLA SACCELIFORMIS

Keenan, n. sp.

Plate 78, figures 21–23

Outline suboval in lateral view, the dorsal and ventral margins nearly parallel, the anterior and posterior margins similar and uniformly curved. Greatest height at midlength, greatest length at midheight, greatest thickness ventral in the posterior half—the valve surface appearing to "bag" downward and slightly backward. Hinge straight and about two-thirds the valve length, dorsal angles equal and obtuse. Valves equal, overlap not ascertained. Surface of valves smooth, no eye tubercle present.

Remarks.—Identification as a species of the genus *Leperditella* is based principally upon hinge characteristics and absence of eye tubercle as overlap of the valves was not ascertained. *L. sacceliformis* differs from other species of the genus *Leperditella* in having the greatest thickness posteroventral, giving the appearance of slight retral swing.

Holotype.—UM 0-982-4; paratypes same slide.

Other Specimens.—USNM 113440.

Genus SCHMIDTELLA Ulrich

SCHMIDTELLA LATIMARGINATA

Keenan, n. sp.

Plate 79, figures 7, 8, 16

Outline in lateral view subcircular, slightly oblong. Middorsal region inflated so as to extend upward above the hinge making the outline of an entire carapace heart-shaped in end view. Hinge straight and about one-half the length of the valve. Free margins slightly inflated so as to form a crescent-shaped border in lateral view, this border widest ventrally and narrowing upward toward each end of the hinge. Contact edges of smaller immature molts rest in the semicircular depression above the swollen border on some specimens. When several immature molts remain, the compound valve appears to be traversed by narrow grooves. Valve surface unornamented by nodes, spines or sulcus.

Remarks.—*S. latimarginata* differs from other species of the genus in having a wide border along the free edge. *S. latimarginata* is closely allied with those species of the genus *Schmidtella* which, until recently have been contained in the genus *Eridoconcha*. In a paper dealing with Bromide (Simpson) ostracodes from Oklahoma, Robbert Drake (1939) shows that specimens from the Simpson formation which have been described as belonging to the genus

Eridoconcha are really compound specimens of *Schmidtella* species.

Holotype.—UM, 0-986-2.

Paratypes.—UM, 0-986-1.

Other specimens.—USNM 113442.

Genus ERIDOCONCHA Ulrich & Bassler

Genotype.—*Eridoconcha rugosa* Ulrich and Bassler, 1923 by original designation = *Placentula marginata* Ulrich, 1890—*Eridoconcha marginata* (Ulrich), n. comb. (Genotype not *Eridoconcha oboloides* Ulrich and Bassler as has been stated by authors).

Carapace oval in lateral view, the straightness of the hinge obscured by swelling of the dorsal margin outward and upward above it. The carapace heart-shaped in end view. The gibbous dorsal region cut by a well-defined sulcus into two unequal, asymmetrical lobes. A narrow fold or lobe commonly parallel with the lower free margins.

Remarks.—It is proposed that the above description be used to supplement the description of the genus by Ulrich and Bassler. Their original generic description (1923, p. 297) was based upon specimens having compound valves, valves consisting of cohering molts. Thus the genus was described to include "small, apparently unequivalved carapaces with concentric, simple or rugose bands or rows of punctae, resembling an equilateral brachiopod in shape and markings." Cross sections of Maquoketa specimens of the species *E. marginata* (Ulrich), the genotype, show that these elevated (rugose) concentric rings are successive buttresses along the free margins of the molts. Most specimens are composed of more than one molt, the contact margin of each smaller molt resting against the base of the buttress on the next larger molt.

At first glance this multiple-molt characteristic appears to be a sound basis for a genus because of its uncommon occurrence. However, at least two distinct ostracode groups have the affinity for immature molt retention—smooth unornamented forms (*Schmidtella*) most prevalent in pre-Cincinnatian strata, and ornamented sulcate forms (*Eridoconcha*) more common in Cincinnatian strata. These genera appear related as both have the inflated dorsal region. The well-defined sulcus and asymmetrical dorsal umbos of the genus *Eridoconcha* are its chief differentiating characteristics.

A comparison of single molts of *E. marginata* (Ulrich) with individuals of other species of the genus *Eridoconcha* as here re-

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EXPLANATION OF PLATE 78

(All figures ×20)

FIGS. *1–7*—Lateral views of specimens from the base of the Eden group at Cincinnati, Ohio. *1—Ctenobolbina bispinosa* Ulrich. *2—Bollia persulcata* Ulrich. *3—Bollia persulcata* Ulrich? (Immature molt). *4—Bythocypris cylindrica* (Hall). *5—Primitiella unicornis* Ulrich. *6—Kiesowia nodosa* (Ulrich). *7—Ceratopsis chambersi* (Miller).

8–34. Specimens from the Maquoketa shale at Castlewood, Missouri.

8–13—Bythocypris cylindrica (Hall). *8–11.* Lateral, ventral, dorsal, and interior views of four large specimens. *12, 13.* Lateral views of two smaller specimens. (p. 567)

14–16—Leperditella dorsicornis Ulrich *14, 15.* Lateral views of left and right valves of a well-preserved specimen showing the shallow sulcus. *16.* Ventral view of a broken specimen showing the overlap. (p. 563)

17—Euprimitia minuta Keenan, n. sp. Lateral view of a right valve, the holotype. (p. 568)

18—Euprimitia floris Keenan, n. sp. Lateral view of a right valve, the holotype. (p. 568)

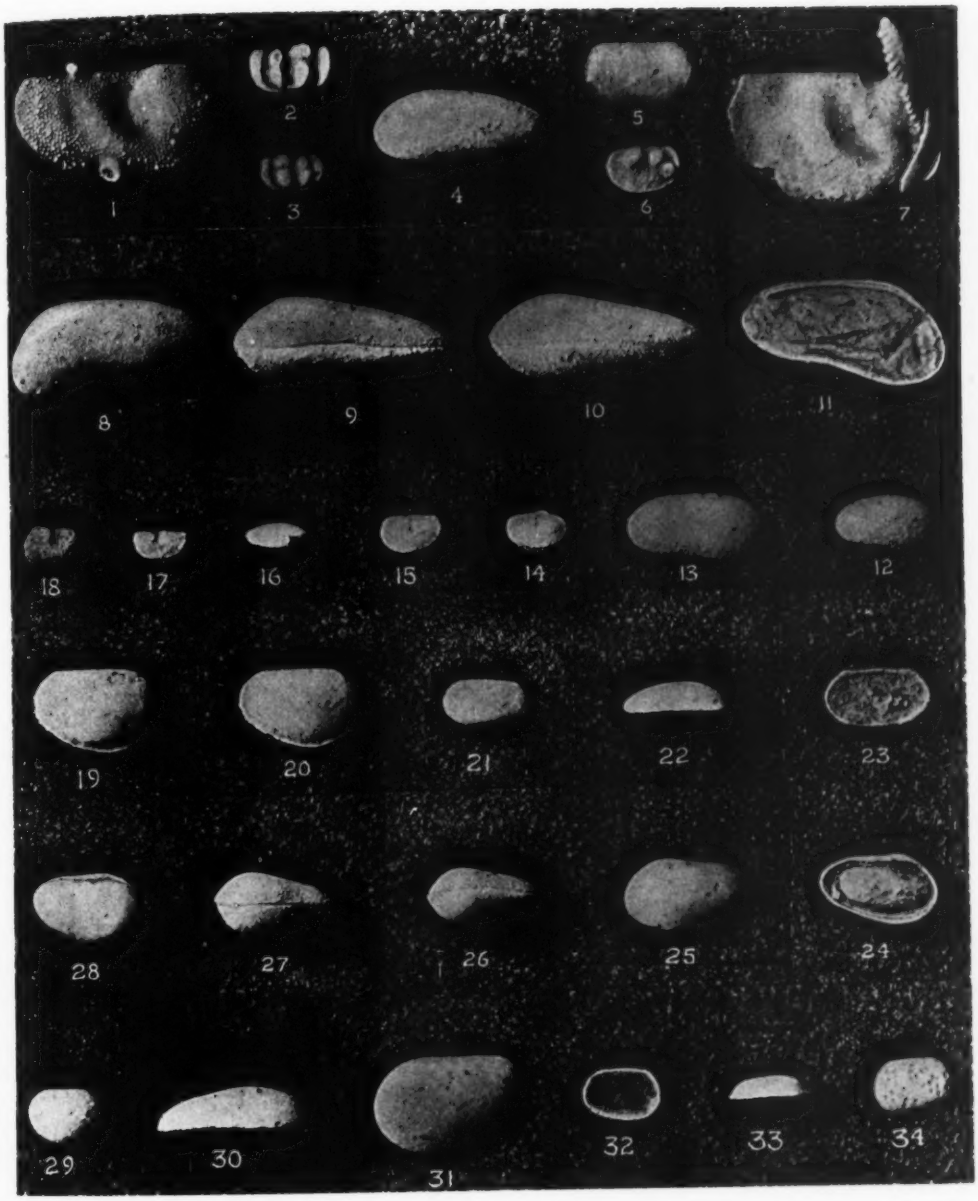
19–20—Aparchites barbatus Keenan, n. sp. *19.* Lateral view of a left valve, the holotype. *20.* Lateral view of a left valve, a paratype. (p. 562)

21–23—Leperditella sacceliformis Keenan, n. sp. *21.* Lateral view of a right valve, the holotype. *22, 23.* Dorsal view of a right valve and interior view of a left valve, paratypes. (p. 563)

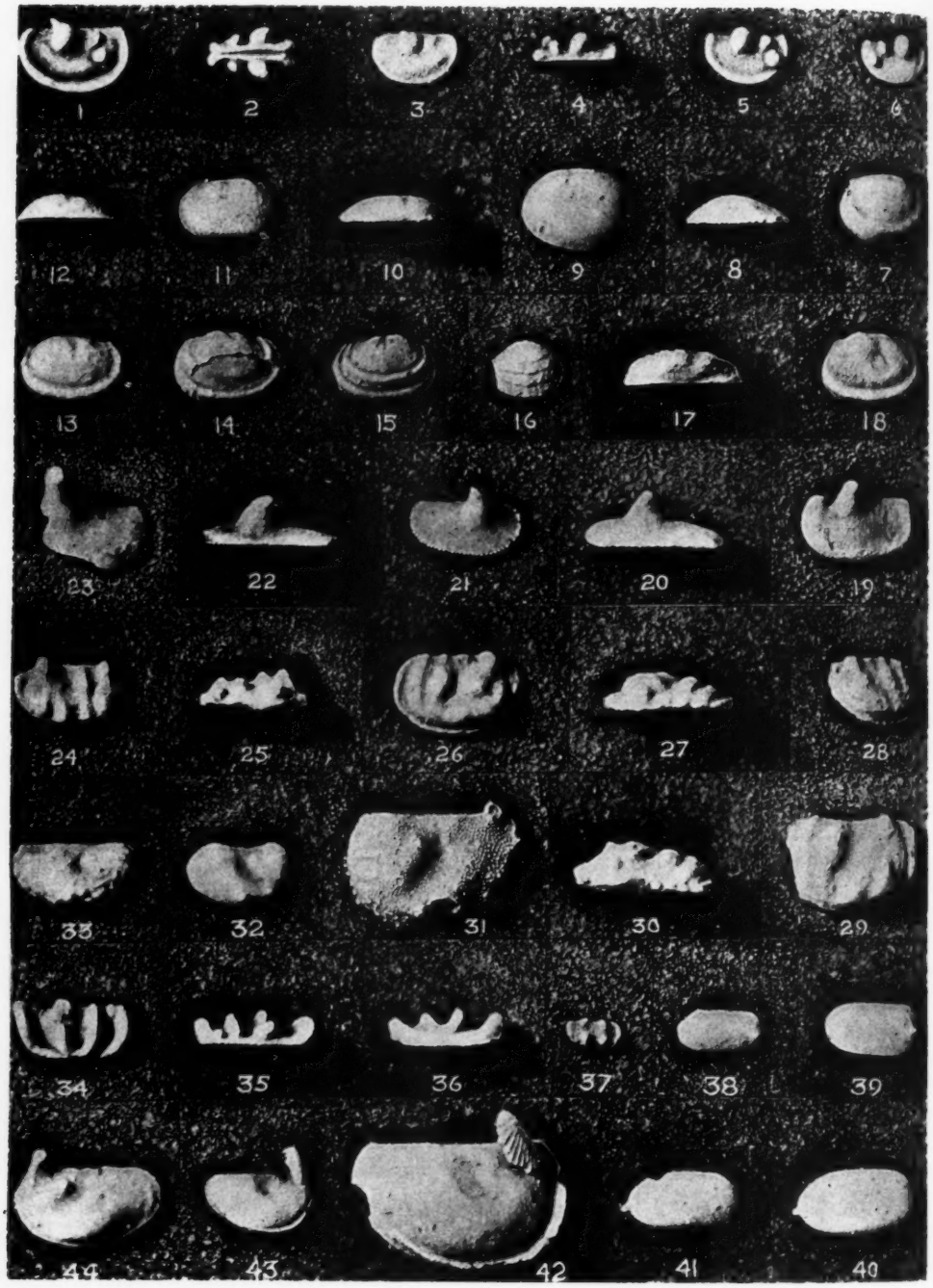
24–28—Bythocypris splendens Keenan, n. sp. *24.* Interior view showing the grooved edge. *25–27.* Lateral, dorsal and ventral views of three paratypes. *28.* Lateral view of the holotype. (p. 567)

29–31—Aparchites trentonensis Ulrich. *29.* Lateral view of a complete small specimen. *30, 31.* Dorsal and lateral views of a large right valve. (p. 562)

32–34—Paraschmidtella irregularis Keenan, n. sp. *32, 33.* Interior and dorsal views of two right valves, paratypes. *34.* Lateral view of a right valve, the holotype. (p. 562)



Keenan, Missouri Maquoketa ostracodes



Keenan, Missouri Maquoketa ostracodes

stricted shows that the important diagnostic features persist. All the species have a swollen dorsal region (are umbonate) and are consequently heart-shaped in end view. Each has a distinct sulcus which divides this dorsal umbo into two asymmetric lobes. In each species the posterior lobe defined by the sulcus extends higher above the hinge than the anterior lobe. In each species the sulcus bifurcates near its lower end. Two species, *E. marginata* (Ulrich) and *E. elegantula* Keenan, n. sp., have pronounced marginal buttresses. As *E. marginata* is the only species retaining immature molts, it appears evident that this property, although it is of definite specific importance has been overemphasized and should not be used as the only structure on which to base a genus.

This concept of the genus *Eridoconcha* excludes certain previously accepted species because they lack the well defined sulcus. Among them are the Simpson species *E. magna* Harris and *E. simpsoni* Harris, and the Decorah species *E. oboloides* Ulrich and Bassler. An examintion of specimens of various Simpson species in the writer's collections shows that they too are compound valves. Considering only the single molts, they fall quite naturally into the genus *Schmidtella*. The affinities of Simpson forms have been discussed by Robert Drake (1939).

The species *Milleratia cincinnatiensis* (Miller) Swartz, genotype of *Milleratia* Swartz, described as having a strong sulcus and asymmetrical dorsal umbos (1936), appears to belong with the genus *Eridocon-*

EXPLANATION OF PLATE 79

(All figures ×20)

FIGS. *1*—*Kiesowia insolens* Keenan n. sp. Lateral view of a left valve, the holotype. One node is broken. (p. 570)

2–3—*Kiesowia binoda* Keenan, n. sp. *2*. Dorsal view of a complete specimen, the holotype. *3*. Lateral view of a left valve, a paratype. (p. 570)

4–6—*Kiesowia verrucosa* Kay. *4*, *5*. Dorsal and lateral views of a right valve. *6*. Lateral view of an interior mold of a left valve. (p. 569)

7, *8*, *16*—*Schmidtella latimarginata* Keenan, n. sp. *7*, *8*. Lateral and dorsal views of a left valve, the holotype. *16*. Lateral view of a specimen with four molts. (p. 563)

9–10—*Eridoconcha gibbera* (Ulrich). Lateral and dorsal views of a left valve. (p. 566)

11, *12*—*Eridoconcha punctata* Keenan, n. sp. *11*. Lateral view of a left valve, the holotype. *12*. Dorsal view of a left valve, a paratype. (p. 566)

13–15—*Eridoconcha marginata* (Ulrich). *13*. Lateral view of a right valve, a single molt. *14*. Right valve retaining half an immature molt. *15*. Left valve consisting of two molts. (p. 566)

17, *18*—*Eridoconcha elegantula* Keenan, n. sp. *17*. Dorsal view of a left valve, a paratype. *18*. Lateral view of a right valve, the holotype. (p. 567)

19, *20*—*Aechmina maquoketensis* Keenan, n. sp. *19*. Lateral view of a right valve, the holotype. *20*. Dorsal view of a left valve, a paratype. (p. 573)

21, *22*—*Aechmina taurea* Keenan, n. sp. *21*. Lateral view of a left valve, the holotype. *22*. Dorsal view of a left valve, a paratype. (p. 573)

23—*Aechmina cuspidata* Jones & Holl. Lateral view of a broken specimen. (p. 572)

24, *25*—*Tetradella septinoda* Keenan, n. sp. Lateral and dorsal views of a left valve, the holotype. (p. 571)

26–28—*Tetradella regularis* Keenan, n. sp. *26*, *27*. Lateral and dorsal views of a right valve, the holotype. *28*. Left valve of different aspect. (p. 570)

29, *30*—*Tetradella carinata* Keenan, n. sp. Lateral and dorsal views of a right valve, the holotype. (p. 571)

31–33—*Ctenobolbina bispinosa* Ulrich. *31*. Lateral view of a large right valve with the anterior lobe broken. *32*. Interior mold of a small left valve. *33*. Left valve of different aspect. (p. 572)

34–37—*Bollia ridicula* Keenan, n. sp. *34*, *35*. Lateral and dorsal views of a left valve, the holotype. *36*. Ventral view of a right valve, a paratype. *37*. Immature molt. (p. 568)

38, *39*—*Primitiella unicornis* Ulrich. Lateral views of two left valves, the first showing shallow punctate grooves and the second smooth. (p. 568)

40, *41*—*Rayella brevicornis* Keenan, n. sp. *40*. Lateral view of a right valve, the holotype. *41*. Same of a paratype. (p. 567)

42–44—*Ceratopsis trilobis* Keenan, n. sp. *42*. Lateral view of a left valve, the holotype. *43*. A smaller left valve, a paratype. *44*. Interior mold of a right valve. (p. 572)

cha. The species *Primitia gibbera* Ulrich, described by Ulrich as having a gibbous dorsal region in addition to the sulcus typical of the genus *Primitia* (1894), should also be included in the *Eridoconcha* as here described. The species *Placentula marginata* Ulrich, later revised to *Jonesites marginatus* (Ulrich) is considered to be synonymous with the species *Eridoconcha rugosa* Ulrich and Bassler (see below).

ERIDOCONCHA MARGINATA (Ulrich)
Plate 79, figures 13–15

Placentula marginata ULRICH, 1890, Cincinnati Soc. Nat. History Jour., vol. 13, p. 124, pl. 10, figs. 13a–c. —— GRABAU and SHIMER, 1910, North American index fossils, vol. 2, p. 351, fig. 1666 d, d′ (p. 360). —— BASSLER, 1915, U. S. Nat. Mus. Bull. 92, p. 982.

Eridoconcha rugosa ULRICH & BASSLER, 1923, Maryland Geol. Surv., Silurian volume, pp. 296, 297, fig. 14 (9).

Jonesites marginatus BASSLER & KELLETT, 1934, Geol. Soc. America Special Pap. 1, p. 349.

Outline suboval in lateral view, the posterior end only slightly higher than the anterior end. Hinge straight and about three-fourths the length of the valve. Greatest length at midheight, greatest thickness somewhat behind midlength. The sulcus wide, prominent, short (extending downward less than a third of the distance from the dorsal border to the ventral border) and divided into two parts at its lower end, both divisions short. Surface of valves smooth. Contact simple. A rounded lobe, semicircular in cross section, parallel with the free edges of the valve, widest ventrally and narrowing gradually as it approaches each end of the hinge. When smaller immature molts are retained their contact margins rest against the inner base of this lobe.

Remarks.—*E. marginata* differs from other species of the genus *Eridoconcha* in retaining immature molts (most specimens retain at least one) and in having a shorter sulcus, a smooth surface, and greater tumidity than other species. It does not have the flat reticulate surface of species of the genus originally described as *Placentula* by Jones and Holl (1886), and later revised to *Jonesites* by Coryell (1930).

Figured specimens.—UM 0-987-3, 0-987-4, 0-987-5.

Similar specimens.—UM 0-987-2; USNM, 113443.

ERIDOCONCHA GIBBERA (Ulrich)
Plate 79, figures 9, 10

Primitia gibbera ULRICH, 1894, Minnesota Geol. Nat. Hist. Survey, vol. 3, pt. 2, p. 655. —— BASSLER, 1915, U. S. Nat. Mus. Bull. 92, p. 1030. —— SPIVEY, 1939, Jour. Paleontology, vol. 13, p. 166, pl. 21, figs. 7, 8.

In his original description of the species *Primitia gibbera*, Ulrich considered the thicker higher lobe to be anterior. In order to be consistent with descriptions of other species of the genus *Eridoconcha*, this paper uses the reverse anterior-posterior orientation considering the dorsal swelling to be highest posteriorly.

Remarks.—The fact that the specimens used for the above description were interior molds probably accounts for their short sulci—the sulcus is longer on the Maquoketa specimens. *E. gibbera* differs from other species of the genus *Eridoconcha* in having a relatively shallower sulcus, a smooth surface, and lacking a well defined marginal lobe.

Figured specimen.—UM, 0-986-3.

Similar specimens.—USNM 113444.

ERIDOCONCHA PUNCTATA Keenan, n. sp.
Plate 79, figures 11, 12

Outline suboval in lateral view, the hinge straight and about two-thirds the length of the valve. The dorsal region inflated, the carapace swollen outward and upward above the hinge, highest posteriorly. Outline heart-shaped in end view. Sulcus deep and prominent, extending downward from the dorsal border to slightly above midheight where it divides into two short parts. An angular interruption in the convexity of the valve, suggesting a lobe, is near and parallel with the free edges of the valve. This low fold appears to be homologous with the marginal buttresses found in other species of the genus *Eridoconcha*. Entire surface, including the sulcus and border, has closely spaced small punctae. Irregular shallow depressions on the carapace contain the small punctae within them as well as between them.

Remarks.—*E. punctata* differs from other species of the genus *Eridoconcha* in having a punctate surface. Like *E. gibbera* it lacks a well defined marginal lobe.

Holotype.—UM, 0-987-1.

Paratypes.—UM, 0-986-4.

Other specimens.—USNM 113445.

ERIDOCONCHA ELEGANTULA
Keenan, n. sp.
Plate 79 figures 17, 18

Outline in lateral view suboval, the hinge straight and about three-fourths the length of the valve. Dorsal region inflated, produced upward above the hinge, highest posteriorly. Carapace heart-shaped in end view. Inflated region divided by a wide prominent sulcus slightly in front of mid-length. Sulcus extending downward from the dorsal border about one-third the distance across the valve, where it divides into two shallow grooves, which join slightly below midheight to surround a low node. A pronounced rounded lobe extends as a semicircular buttress near to and parallel with the free edges of the valve. Free edges thickened, contact simple. Surface of most specimens granular, some apparently smooth. Central node smooth.

Remarks.—*E. elegantula* differs from other species of *Eridoconcha* in having a granular, less tumid surface, and in having a longer more prominent sulcus which splits and reunites at its lower end to surround a central node. It most closely resembles the species described by F. M. Swartz (1936, p. 567) as *Milleratia cincinnatiensis* (Miller) but differs in having a well developed submarginal lobe.

Holotype.—UM 0-988-4.
Paratypes.—UM 0-988-3, 0-988-2.
Other specimens.—USNM 113446.

Family BAIRDIIDAE Lienenklaus
Genus BYTHOCYPRIS Brady
BYTHOCYPRIS CYLINDRICA (Hall)
Plate 78, figures 4, 8–13

Leperditia (*Isochilina*) *cylindrica* HALL, 1872, Twenty-fourth Rep. State Cab. Nat. Hist. New York, p. 231.
Bythocypris cylindrica ULRICH, 1889, Geol. Nat. History Survey Canada, Contr. Micropaleontology, pt. 2, p. 48, pl. 9, fig. 6.

Hall's description:

Carapace minute, seldom exceeding two-hundredths of an inch in length, nearly twice as long as wide; valves very convex and cylindrical, the anterior and posterior ends subequal and strongly rounded; cardinal line much shorter than the length of the valve; tubercle obsolete. Surface smooth.

Remarks.—The large specimens of this species from the Maquoketa of Missouri are more arcuate back of the hinge and are more concave (upward) in ventral outline than the typical specimens described by Hall. They are undoubtedly of the same species, as the smaller specimens show complete intergradations in size and shape.

Figured specimens.—UM 0-980-5, 0-981-1, 0-981-2.

Similar specimens.—USNM 113436, 113437.

BYTHOCYPRIS SPLENDENS
Keenan, n. sp.
Plate 78, figures 24–28

Outline oval in lateral, top and bottom views, nearly circular in end view. Greatest length at midheight, greatest height and thickness in posterior third. The hinge about one-half the valve length, straight, obscured by overlap when the two valves are united. The right valve considerably larger than the left and overlapping it on all edges, the greatest amount of overlap at the hinge. Interior edges of the right valve grooved to intercept the smaller left valve. Surface of valves smooth.

Remarks.—The unique "pear" shape distinguishes this species. It resembles late Paleozoic species of the genus *Cytherella*, having somewhat similar overlap, but differs principally in being more cylindrical, though tapering, in shape. It most closely resembles the species *Bythocypris siliqua* Jones and Holl but does not have the rhythmic variations in shell thickness of that species. It is the most abundant species at the Castlewood, Missouri, locality with the different individuals showing little variation other than in size.

Holotype.—UM 0-983-3.
Paratypes.—UM 0-983-1, 0-983-2, 0.982-5.
Other specimens.—USNM 113438.

Family BEECHERELLIDAE Ulrich
Genus RAYELLA Teichert
RAYELLA BREVICORNIS Keenan, n. sp.
Plate 79, figures 40, 41

Krausella inaequalis ? SPIVEY, 1939, Jour. Paleontology, vol. 13, pp. 172–173.

Outline approximately oval in lateral view but with the ventral margin nearly straight. The dorsal margin uniformly convex and rising slightly higher than the hinge at midlength. Hinge straight and about one-half the length of the valve. Valve uniformly tumid, smooth. Right valve with a

small discrete spine projecting straight backward from slightly below midheight. Ventral overlap assumed but not definitely determined as only separated valves have been examined.

Remarks.—Dorsal overlap characteristic of the genus *Krausella* is improbable because of the straightness of the hinge and the swelling of part of the dorsal margin upward above the hinge. In typical specimens of *Krausella* the dorsal overlap completely obscures the hinge and the dorsal edge is broadly curved.

The only specimens accurately determined to be *R. brevicornis* are isolated right valves. As the posterior spine is discrete on the right valve there is probably no corresponding ornamentation on the left. Hence any left valves present in the assemblage probably resemble specimens of *Bythocypris* closely enough to make correct identification difficult.

Holotype.—UM 0-993-1.

Paratypes.—UM 0-993-2, 0-992-5.

Other specimens.—USNM 113454.

Family PRIMITIIDAE Ulrich & Bassler

Genus EUPRIMITIA Ulrich & Bassler

EUPRIMITIA MINUTA Keenan, n. sp.

Plate 78, figure 17

Outline semielliptical in lateral view. The dorsal margin nearly straight, very slightly convex just in front of the sulcus. Valve longest immediately below the hinge, highest in posterior third, thickest about the center. The sulcus shallow, situated just behind midlength, widening downward and backward to partially surround an almost imperceptible node. A narrow, thick, smooth border parallel with the free edges of the valve. Except for the border and the partly obscured node, the surface finely reticulate; the reticulations lined up so as to form crude semicircles around the sulcus as center.

Remarks.—*E. minuta* differs from other described species of the genus *Euprimitia* in being more elongate with the greatest length just below the hinge. It is a much smaller than average species, and is the smallest species found in the Maquoketa assemblage.

Holotype.—UM 0-982-1.

Paratypes.—UM 0-981-5.

Similar specimens.—USNM 113448.

EUPRIMITIA FLORIS Keenan, n. sp.

Plate 78, figure 18

Outline oval to rectangular in lateral veiw. The hinge about two-thirds the length of the valve. The dorsal angles broadly rounded, the dorsal and ventral margins straight, the anterior and posterior margins semicircular. Greatest length at midheight, greatest height in anterior third, greatest thickness in posterior third. The sulcus prominent, somewhat behind midlength, extending downward from the dorsal margin to midheight. Excepting the sulcus the entire surface reticulate, each reticulation flowerlike in outline—having four to six small petal-shaped marginal excavations. Border very narrow, valves similar.

Remarks.—The petaloid shape of the reticulations distinguishes this species. This characteristic is usually quite obvious even on poorly preserved specimens.

Holotype.—UM 0-982-2 paratypes same slide.

Other specimens.—USNM 113447.

Genus PRIMITIELLA Ulrich

PRIMITIELLA UNICORNIS (Ulrich)

Plate 78, figure 5; plate 79, figures 38, 39

Leperditia unicornis ULRICH, 1879, Cincinnati Soc. Nat. History Jour., vol. 2, p. 10.

Aparchites unicornis ? ULRICH, 1889, Contr. Canadian Micropaleontology, part 2, p. 50.

Primitia unicornis ? JONES, 1890, Geol. Soc. London, Quart. Jour., vol. 46, p. 7.

Primitiella unicornis ULRICH, 1894, Minnesota Geol. Nat. History Survey, vol. 3, pt. 2, p. 649.

Remarks.—Specimens of the species *Primitiella unicornis* from the Maquoketa shale at Castlewood, Missouri, seem identical with the specimens described and figured by Ulrich from the lower Cincinnatian beds (Utica) at Covington, Kentucky (1894, page 649). They also compare closely with specimens from the Eden (lower Cincinnatian) at Cincinnati, Ohio (see plate 79, figure 5). The posteriorly projecting spine distinguishes the species.

Figured specimens.—UM 0-992-3, 0-992-4.

Similar specimens.—USNM 113449, 113450.

Genus BOLLIA Jones & Holl

BOLLIA RIDICULA Keenan, n. sp.

Plate 79, figures 34–37

Outline in lateral view roughly a paral-

lelogram about twice as long as high with a very slightly curved (concave upward) dorsal margin. Posterodorsal angle obtuse, anterodorsal angle acute, the carapace showing retral swing. Both anterior and posterior ventral corners broadly rounded, the midlength of the ventral margin straight. The marginal lobe a continuous folded narrow ridge extending laterally from the free edges; the anterior part exceptionally thin and prominent, projecting slightly above the dorsal margin and hiding the anterior end of the hinge in lateral view; the ventral part depressed; the posterior part prominent and somewhat wider than the anterior part, with a small round node just in front of its junction with the hinge. The median horseshoe-like lobe with exceptionally high anterior and posterior limbs; the posterior limb continuous and the anterior limb divided by a short sulcus making its dorsal end a separate node which projects upward above the hinge. Ventral connecting lobe of the horseshoe ridge depressed, appearing almost confluent with the marginal ridge when seen in lateral view.

Remarks.—This species most closely resembles *Bollia persulcata* Ulrich (1890), but differs in having a small discrete node just in front of the posterodorsal corner of the border, in having narrower and higher ridge ornamentation with broader depressions between, and in having pronounced retral swing. Specimens of *B. persulcata* from the Eden group at Cincinnati, Ohio, are illustrated for comparative purposes, (plate 79, figures 2, 3). The only other described Maquoketa species, *Bollia ruthae* Spivey (1939), is shorter and does not have the short sulcus separating the anterior limb of the median horseshoe lobe.

Holotype.—UM 0-991-5.

Paratypes.—UM 0-991-4, 0-992-1.

Figured immature molt.—UM 0-992-2.

Others specimens.—USNM 113457.

Genus KIESOWIA Ulrich & Bassler

Genotype.—*Beyrichia dissecta* Krause, Deutsche Geol. Ges., Zeitschr., vol. 44, p. 292, 1892.

Ulrich and Bassler first described the genus *Kiesowia* in 1908 (page 307). In 1923 they summarized the original description to read: "like *Tetradella* except that the two anterior and posterior lobes are each divided into two or three nodes", G. M. Kay later submitted the following description for the genus (1940, p. 234):

> Valves small, similar. Outline truncate elliptical. Surface relatively depressed, with thickened border; bearing a variable number of distinct nodes within. Contact seems simple.
>
> This genus, which has been compared to *Tetradella* in the past, is most similar to the genus *Ulrichia*, having two dorsal nodes and a reticulate surface as in that genus; it differs principally in having a number of marginal and submarginal nodes.

Remarks.—Originally most *Kiesowia* species were classified as species of the genera *Beyrichia* or *Tetradella*. One species reclassified recently as *Kiesowia nodosa* (Ulrich) by Kay (1940, p. 234) has been figured sucessively as *Primitia nodosa* Ulrich (1890, p. 134), *Ulrichia nodosa* Ulrich (1891, p. 203), and *Warthinia nodosa* (Ulrich) Spivey (1939, p. 167). A specimen of this species from the Eden group at Cincinnati, Ohio is illustrated to show its similarity to the Maquoketa species *Kiesowia verrucosa* Kay (plate 78 figure 6).

KIESOWIA VERRUCOSA Kay
Plate 79, figures 4–6

Kiesowia verrucosa KAY, 1940, Jour. Paleontology, vol. 14, p. 260.

Outline semicircular to semielliptical in lateral view, the hinge straight. Longest part of valve slightly below the hinge. Valve highest at midlength. Excepting nodes and border the surface relatively flat, the thickness of the valves fairly uniform. Valve surface marked with pits about 0.02 mm. in diameter, distance between pits about 0.005 mm. A raised smooth border, semicircular in cross section, extends along the free edges of the valve and from the posterodorsal end a short spine continues upward slightly above the hinge. Surface contains three prominent nodes. Both node and border marked with very small pits about 0.002 mm. in diameter, distance between pits about 0.002 mm. The largest node projecting outward and upward above the hinge from slightly in front of midlength, a smaller one projecting above the hinge from slightly behind midlength, and another, small, adjacent to the posterior part of the border at midheight.

Remarks.—*K. verrucosa* most closely resembles *K. nodosa* (Ulrich), (plate 78, figure

6), having the three nodes in similar position. It differs mainly in having sharper dorsal angles with a short posterodorsal spine, in having the two principal nodes project above the hinge in lateral view, and in having a more prominent border.

Figured specimens.—UM 0-985-4, 0-985-5.
Similar specimens.—USNM 113451.

KIESOWIA BINODA Keenan, n. sp.
Plate 79, figures 2, 3

Outline semicircular in lateral view, the hinge straight and the dorsal angles rounded. Greatest length just below the hinge, greatest height about midlength, greatest thickness (excluding the nodes) at midheight in the posterior third. The valves irregularly convex and ornamented with two nodes. The larger node projects outward and upward from just in front of midlength and terminates in a short cusp which points forward; the smaller node (without a cusp) extends outward and only slightly upward to the hinge from just behind midlength. Except for the narrow low border and for the ends of the cusp and node, the surface finely and regularly reticulate. Contact of the valves simple.

Remarks.—*K. binoda* differs from other species of *Kiesowia* in having only two nodes. The valves are more convex and the border is lower and narrower than in other species.

Holotype.—UM 0-985-2.
Paratypes.—UM 0-985-3, 0-985-1.
Other specimens.—USNM 113452.

KIESOWIA INSOLENS Keenan, n. sp.
Plate 79, figure 1

Outline approximately semicircular in lateral view, the hinge straight and the dorsal angles rounded. Greatest length just above midheight, greatest height at midlength, greatest thickness about the center but only slightly greater here than at the free margins. Free edges folded outward into a thick false border with a wide groove just inside. Surface ornamented with three prominent nodes. The largest node, circular in cross section, situated in front of a median sulcus, produced outward and upward above the hinge, and terminated in a short cusp which curves forward. A somewhat smaller node, oval in cross section, situated just behind the median sulcus, extends outward and upward above the hinge, and terminates in a short outward curving cusp. The smallest node, circular in cross section, situated just in front of the posterior false border at midheight, extends directly outward and terminates in a well rounded blunt point. The surface, including nodes and border, is covered with small shallow punctae. Contact of the valves simple.

Remarks.—*K. insolens* differs from other species of the genus *Kiesowia* in having the posterodorsal node oval in cross section, capped with a short curved cusp, and extending considerably above the hinge. It is the only described species with a thick "folded" submarginal false border. It differs from *K. verrucosa* in the punctae on the nodes and margin being much smaller than those on the remainder of the test.

Holotype.—UM 0-984-5.
Paratypes.—UM 0-984-4.
Other specimens.—USNM 113453.

Family TETRADELLIDAE Swartz
Genus TETRADELLA Ulrich
TETRADELLA REGULARIS Keenan, n. sp.
Plate 79, figures 26–28

Outline suboval in lateral view, the dorsal margin sinuous because of the projection of the posterior and anterior lobes upward above the hinge. Retral swing prominent. Anterodorsal angle acute, posterodorsal angle obtuse, both well rounded. Carapace divided into four vertical lobes, all ventrally connected; the low saddle-shaped connections causing the carapace to appear to be traversed by a continous undulating sickle-shaped lobe parallel with the posterior, the ventral, and the lower anterior free edges. The posterior lobe parallel with the broadly curving posterior margin, extends upward slightly above the hinge. The median lobe trends upward and somewhat forward three-fourths of the distance across the valve to the hinge; separated from the posterior lobe by a shallow sulcus and from the back part of the anterior lobe by a relatively deep sulcus. The anterior lobe consists of a front and a back part, ventrally united. The back part undulates, having three prominent node-like "highs," one at each end, and one at midlength. This portion of the lobe trends anterodorsally across the

valve and terminates in a node extending upward above the hinge. The front part of the anterior lobe curved, short, receding into the valve surface at about midheight. The dorsal border with two small nodes evenly spaced between the extensions of the posterior and the anterior lobes above the hinge. A low continuous flat border along the free edges.

Remarks.—The undulating, nodose character of the lobes distinguishes this species from Trenton species of the genus *Tetradella*. It does not have the carinate ridges of *T. carinata* or the discrete nodes of *T. septinoda*, other Maquoketa species of the genus.

Holotype.—UM 0-990-3.

Paratypes.—UM 0-990-4, 0-990-2.

Other specimens.—USNM 113458.

TETRADELLA SEPTINODA Keenan, n. sp.
Plate 79, figures 24, 25

Outline in lateral view varying from subovate to semicircular. The dorsal margin straight except for two places where interrupted by nodes extending above the hinge. Valve longest at midheight, highest at midlength, thickest anteroventrally through the front ventral node of the anterior lobe. Lobation indistinct—the position of the four vertical lobes typical of the genus *Tetradella* indicated by nodes, seven nodes ornamenting the surface of a valve. A posterodorsal node just in front of the posterior margin and extending a short distance above the hinge, and a posteroventral node just above the border directly below the first node, mark the position of the posterior lobe found in other species of the genus *Tetradella*. A third and a fourth node, forward from and each respectively lower than the first and second nodes mentioned, mark the position of the median lobe (of other species of the genus *Tetradella*) which does not quite reach the dorsal margin. A fifth node, anterodorsal and projecting above the hinge, together with the sixth and seventh nodes located just above the ventral border successively in front of the second and the fourth nodes previously mentioned, mark the position of the anterior lobe. The free edges are bounded by a low continuous flat border. Valve surfaces smooth.

Remarks.—Although *T. septinoda* is strikingly contrasting in general appearance, its close relationship to *T. regularis* and *T. carinata* is shown by the position of the nodes on the valves. Each of the nodes of *T. septinoda* is matched by a corresponding relative thickening of the lobe on the species *T. regularis* and *T. carinata*. Specimens of *T. septinoda* are often preserved in a hard shaly matrix with only the carapace margins and the seven nodes showing through the matrix.

Holotype.—UM 0-990-1.

Paratypes.—UM 0-989-5.

Other Specimens.—USNM 113459.

TETRADELLA CARINATA Keenan, n. sp.
Plate 79, figures 29, 30

Outline suboval in lateral view, the dorsal margin straight except where interrupted by the posterior and the anterior lobes projecting upward above the hinge. Greatest length at midheight, greatest height at midlength, greatest thickness in anteroventral quarter through the front anterior lobe. Valve surface divided into four vertical lobes with sulci between, the lobes ventrally connected. The posterior lobe parallel with the broadly curved posterior border and extending upward slightly above the hinge. The median lobe separated from the posterior lobe by a narrow shallow sulcus, extending upward not quite to the hinge. The anterior lobe separated into two parts, the front part curved forward and upward, short, receding into the valve surface at about midheight; the rear part separated from the median lobe by a relatively deep and wide sulcus and extending anterodorsally across the anterior half of the valve, projecting slightly above the hinge. A sharp, carinate ridge extending continuously along the crest of the lobes, including their ventral connections. A low flat continuous border parallel with the free edges of the valve.

Remarks.—*T. carinata* differs from other species of *Tetradella* in having carinate ridges along the lobes. The placement of the lobes is similar to that of *T. regularis*. Specimens of *T. carinata* are commonly preserved buried in a hard shaly matrix with only the carapace margins and carinate ridges showing through the matrix.

Holotype.—UM 0-990-5.

Other specimens.—USNM 113460.

Genus CERATOPSIS Ulrich
CERATOPSIS TRILOBIS Keenan, n. sp.
Plate 79, figures 42–44

Outline oval in lateral view except for the straight hinge line. Hinge about four-fifths the valve's greatest length. Valve longest in dorsal third, highest in posterior half, and thickest ventrally about midlength of the valve. Valve quite tumid and with only three lobes instead of the four typical of the genus *Ceratopsis*. The fused anterior and median lobes occupying the front half and most of the lower part of the valve (about three-fourths the valve area), and showing a pronounced anterodorsal trend. The postmedian lobe short, low, and narrow, extending upward and forward across the valve halfway to the hinge from its posteroventral junction with the anterior median lobe. The posterior lobe little more than a base for the distinctive fimbriate spike extending outward, upward, and forward from a posterodorsal position on the valve. Length of the spike equal to about one-half the height of the valve. The spike forming the base for from ten to 12 small discrete spines set much in the same manner as the teeth of a comb, the spines near the base of the spike pointing downward, those near the tip pointing forward, and the remainder with successive intermediate direction. The valve with a smooth false border or flange parallel with the free edges, most prominent posteriorly and receding into the carapace anterodorsally. Surface of the valves commonly covered with tiny confluent shallow depressions (not true pits or reticulations) but some specimens apparently smooth.

Remarks.—*Ceratopsis trilobis* differs from other species of the genus in having the typical anterior and median lobes fused into a single prominent lobe.

Holotype.—UM 0-993-3.
Paratypes.—UM 0-993-4, 0-993-5.
Other specimens.—USNM 113455.

Family HOLLINIDAE Swartz
Genus CTENOBOLBINA Ulrich
CTENOBOLBINA BISPINOSA Ulrich
Plate 78, figure 1; plate 79, figures 31–33

Ctenobolbina bispinosa ULRICH, 1890, Cincinnati Soc. Nat. History Jour, vol. 13, p. 110.

Specimens of the species *Ctenobolbina bispinosa* from the Maquoketa of Missouri are practically identical with those from the basal Cincinnatian (Eden) from Cincinnati, Ohio, described by Ulrich.

Maquoketa figured specimens.—UM 0-991-1, 0-991-2, 0-991-3.

Similar specimens.—USNM 113456.

Family AECHMINIDAE Swartz
Genus AECHMINA Jones & Holl

Genotype.—*Aechmina cuspidata* Jones and Holl, 1869 (not *Aechmina bovina* Jones as has been stated by authors).

AECHMINA CUSPIDATA Jones & Holl
Plate 79, figure 23

Aechmina cuspidata JONES & HOLL, 1869, Ann. Mag. Nat. History, ser. 4, vol. 3, p. 218.

Part of Jones and Holl's specific description:

> Carapace-valve suboblong, convex and produced at the middle (towards the posterodorsal region) into a stout sharp spike; dorsal edge straight, ventral edge elliptical; one end more broadly rounded than the other.
>
> We have here evidently a very close approximation to Professor James Hall's *Cytherina (Aechmina) spinosa* (Palaeont. New York, Vol. ii, p. 317, pl. 67, figs. 17–21), from the Niagara Shale at Lockport, in the State of New York; but the latter is more quadrate in outline and somewhat depressed at the root of the spine, which, though nearly central, is near the dorsal margin.

In a later publication (1887, page 411) Jones stated:

> . . . The end views may be roughly compared with a three-rayed star, in which the lower portion is somewhat thickened.

Remarks.—The above description applies in general to the entire genus *Aechmina;* to clearly distinguish the species *A. cuspidata* some additional notes are advisable. An illustration accompanying some of Jones' later descriptions (1887, plate 13, figure 9), and a discussion of the genus by Jones (1887, p. 411), show that the species *A. cuspidata* has a row of small marginal spines not mentioned in the original specific description (1869, p. 218). Observations of Maquoketa specimens prove that these spines are not literally marginal but are extended from a false border whose position is lateral to the true contact edges of the valve. The spines are similar to those of the species *A. bovina*

Jones and *A. taurea* Keenan, n. sp. Except for a slight variation of outline shown by some specimens, these species differ only in the characteristics of the distinctive dorsal spike. In describing the species *A. bovina*, Jones illustrated this difference from *A. cuspidata* (1887, p. 412):

> . . . The hollow spike or horn is thicker than in *Aech. cuspidata*, its base taking up a larger portion of the valve's surface; it is also shorter and has a slight curve upwards and inwards.
>
> . . . Seen endwise the carapace, with its valves united . . . , reminds us of the aspect presented by the face and front of some of the *Bovidae* while figures . . . of *Aech. cuspidata* have more analogy to the long straight horns of some antelopes.

The spike of *A. taurea* Keenan, n. sp. does not extend as high above the hinge as do those of *A. bovina* and *A. cuspidata*. It is much shorter, extending mostly outward and only slightly upward.

Figured specimen.—UM 0-989-4, other specimens on same slide.

Similar specimens.—USNM 113432.

AECHMINA TAUREA Keenan, n. sp.
Plate 79, figures 21, 22

Outline suboval in lateral view, the dorsal margin straight (except for the protrusion of the spike above the hinge), the ventral margin gently convex, the anterior and posterior margins uniformly well rounded. Greatest length at midheight, greatest height in posterior third, greatest thickness at base of spike. Retral swing slight. The dorsal spike situated just behind midlength, its base occupying approximately one-eighth the valve area, relatively short, extending mostly outward and only slightly forward and upward. A submarginal false border just lateral to the true contact edges of the valve, forming the base for a row of small spines; this false border hides the contact edges of the valve in lateral view. Surface of the valves smooth.

Remarks.—*A. taurea* Keenan, n. sp. most closely resembles the spinose-frilled species *A. cuspidata* Jones and Holl and *A. bovina* Jones. Its dorsal spike is much shorter and does not extend as far above the hinge as does that of *A. cuspidata* or *A. bovina*. It is also more elongate with slight retral swing, and has the spike situated farther back on the carapace. *A. cuspidata* and *A. bovina* have a more nearly semicircular outline in lateral view with the spike situated about midlength of the valve.

Holotype.—UM 0-989-2.

Paratypes.—UM 0-989-3.

Other specimens.—USNM 113433.

AECHMINA MAQUOKETENSIS Keenan, n. sp.
Plate 79, figures 19, 20

Carapace suboval in lateral view, the dorsal margin straight. The hinge line slightly shorter than the longest part of the valve. Greatest length at midheight, greatest height and thickness in the posterior third. Base of the spike occupying somewhat less than one-twelfth the surface area of the valve. The spike situated in the third quarter from the anterior end, in the dorsal third, and projecting laterally and upward above the hinge a distance equal to about one-third the valve height. The surface slightly depressed just back of and partially surrounding the spike. The entire surface including the spike and depression evenly and minutely granular—the surface actually covered with very minute rounded nodes arranged in curving rows, 80 to 100 nodes lengthwise across the valve. These nodes obscured on less perfectly preserved specimens, the surface appearing smooth.

Remarks.—*A. maquoketensis* most closely resembles the species *A. richmondensis* Ulrich and Bassler. It differs in having a granular surface and in having a depression just back of the spike.

Holotype.—UM 0-988-5.

Paratypes.—UM 0-989-1.

Other specimens.—USNM 113431.

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A NEW OSTRACODE GENUS FROM THE CRETACEOUS BEAR RIVER FORMATION

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ABSTRACT—A new genus of ostracodes, *Looneyella*, is described from the nonmarine Cretaceous Bear River formation with two species. The new genus is closely related to *Hutsonia* Swain.

THE nonmarine sediments of Jurassic, Cretaceous and Tertiary age in the Rocky Mountain area yield varied and characteristic assemblages of microfossils. This is especially true of the Bear River formation of Cretaceous age in western Wyoming. This formation, near the southern terminus of its outcrop in Uinta County, is exceptionally fossiliferous and most of the fossils are well preserved.

The larger Bear River invertebrates were ably described by White in 1895. White also discussed the unusual components of the Bear River fauna, giving especial attention to the occurrence of the gastropod *Pyrgulifera* and the association of characteristic brackish and fresh-water types. Jones (1893) had described the ostracodes two years earlier from some acidized material sent to him by the U. S. Geological Survey from near Cokeville, Wyoming. Knowlton (1893) described one charophyte species from the Bear River.

The Bear River ostracode fauna consists primarily of Cyprideinae (*Cypridea* s. l.) and metacyprids. There also occurs in this fauna, in close association with the typical Cyprideinae and metacyprids, an ostracode of uncertain affinities that sufficiently differs from all described forms to merit the establishment of a new genus. At present the new genus is known only from the Bear River formation. It is hoped that publication of illustrations and a description of the genus will lead to the recording of its occurrence in other formations from other localities.

The samples from which the ostracodes were obtained were collected by Mr. Hugh Looney and the writer from the Bear River formation at the following localities near Evanston, Uinta County, Wyoming:

Locality 37.—Sulphur Creek in sec. 29, T. 14 N., R. 119 W., 9 miles southeast of Evanston, Wyoming (type locality). Samples taken in fossiliferous thin layers of dark carbonaceous shales, with thin bands of interbedded sandstones, limestones, and thin seams of coal exposed in the cut of an old abandoned railroad grade on the north side of Sulphur Creek.

Locality 38—Shell Hollow in the $E\frac{1}{2}$ $SE\frac{1}{4}$, sec. 12, T. 16 N., R. 121 W., 7 miles north of Evanston, Wyoming, on the east side of Highway 89. Samples taken in fossiliferous dark carbonaceous shales, with thin bands of interbedded sandstones, limestones, and coal seams, in lower 300 feet of exposure.

The illustrations are retouched photographs and were prepared by Vaona Hedrick Peck.

Genus LOONEYELLA Peck, new genus

Type species: Cythere monticula Jones, Bear River formation, Uinta County, Wyoming.

Carapace subtrigonal to subpyriform in lateral outline, with dorsal and ventral margins converging posteriorly from the greatest height at the anterocardinal angle to a well developed caudal process; alate, the alae terminating posteriorly in spines on some species; lobed, the posterior lobe produced into a strong node or spine. Left valve the larger, overlapping strongly along the hinge and on the upper part of the anterior margin.

The right valve possesses elongate teeth with numerous crenulations at each end of the hinge, the teeth connected by a shallow groove parallel to the margin of the shell. Dentition of left valve the opposite of the right with sockets recessed under prominent overlap.

Inner and outer margins approximately parallel, inner margin coinciding with line of concrescence, radial pores few or absent, muscle scars not observed. Dimorphism unknown in the genus.

Relationships.—*Looneyella* is closely related to and may have developed from *Hutsonia* Swain, from the Upper Jurassic. *Hutsonia* is smaller, does not overlap along the hinge except at the anterior margin, and does not develop alae and spines. The sulci are more strongly developed on representatives of *Hutsonia* than on *Looneyella*. The generic name is in honor of Mr. Hugh Looney, who collected several of the paratypes.

LOONEYELLA MONTICULA (Jones)
Plate 80, figures 1–6

Cythere monticula JONES, 1893, Geol. Mag. dec. 3, vol. 10, p. 389, pl. 15, figs. 13 a, b.
Cythere monticula WHITE, 1895, U. S. Geol. Survey Bull. 128, (reproduction of Jones' plate).

Carapace small, measuring from 0.6 to 0.7 mm. in length, and about 0.4 mm. in height; roughly trigonal in lateral outline. Dorsal margin fairly straight with slight concavity in center, anterior margin truncate above and rounding into ventral margin in lower third, ventral margin convex with slight flexure of edge of valves to produce concavity at the center; dorsal and ventral margins almost meeting at the posterior end of the caudal process. Surface of valves coarsely reticulate, the pits shallow. Alae well developed with prominent longitudinal ribs on ventral surface possibly representing growth stages. The alae produce a flattened ventral surface, convex longitudinally.

Three lobes are separated by shallow sulci. The elongate anterior lobe lies near the center of the anterior margin, and the others are located dorsally. The center lobe is rounded, low, the least prominent of the three, and the posterior lobe is produced into a large blunt spine. The anterior and posterior ends of the carapace are blunt.

Remarks.—The description is based on about 90 specimens. There is some variation in size but molt stages have not been definitely recognized. Relationships are discussed above under the generic description.

Distribution.—Common in the Bear River formation on Sulphur Creek and in Shell Hollow, near Evanston, Uinta County, Wyoming.

Types.—Primary types probably in the British Museum. Figured specimens, Univ. Missouri 0-1097-1, 0-1098-1-5.

LOONEYELLA QUADRISPINA Peck, n. sp.
Plate 80, figures 7–9

Fairly large carapace, the holotype measuring 0.8 mm. in length and 0.5 mm. in height, roughly trigonal in lateral outline (subquadrate when caudal process is broken); and with two large blunt spines on each valve, the ventral spines produced at the posterior-lateral ends of the alae and the dorsal spines on the posterior lobes. Surface of valves roughly reticulate, the pits shallow.

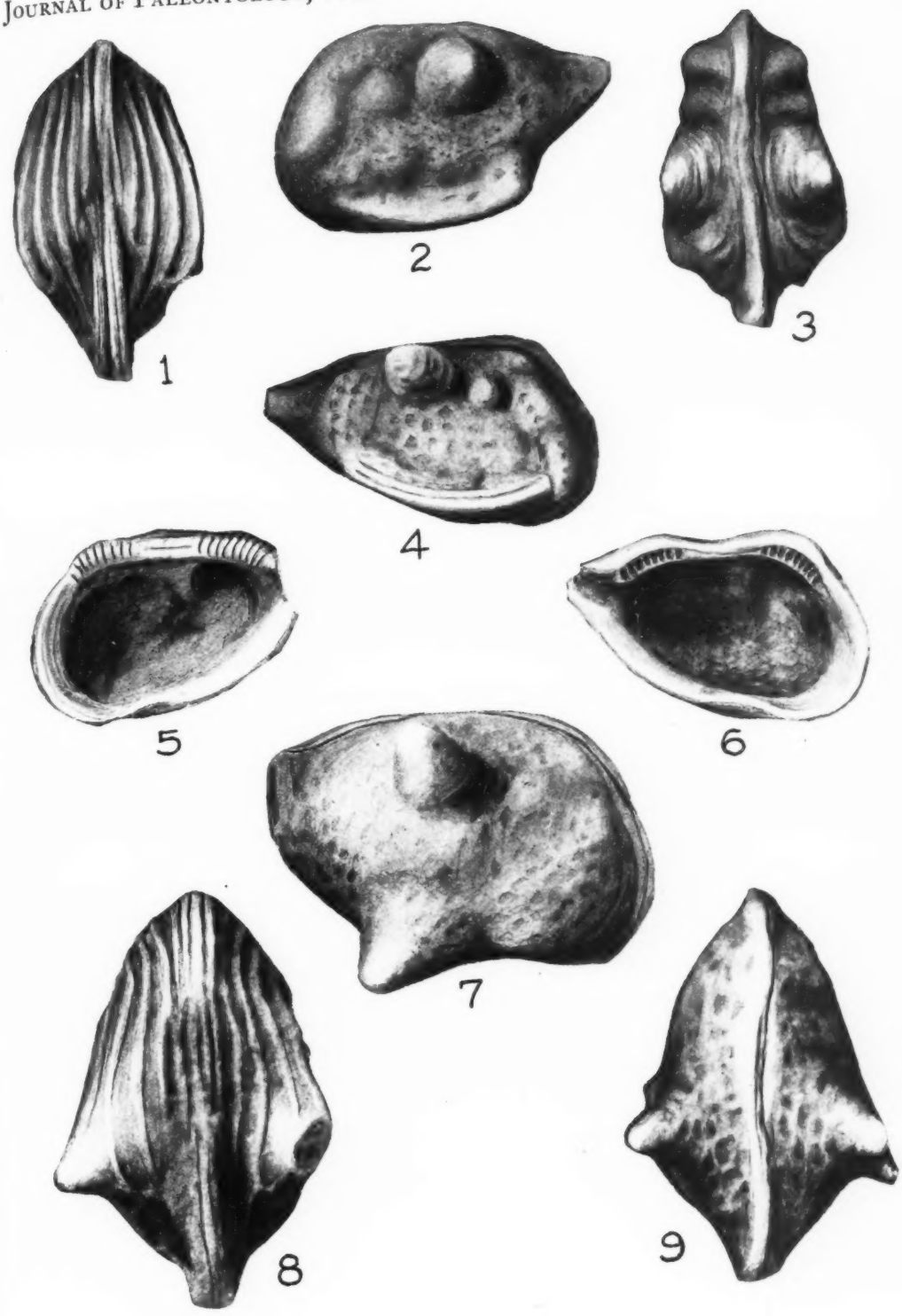
Remarks.—The description of this species is based on three specimens. The holotype is complete and well preserved, the two paratypes are single valves and the preservation is only fair. *C. quadrispina* differs from *C. monticula* in the larger size, the development of the spines on the posterior lateral edges of the alae, and in the less prominent anterior and central lobes.

Distribution.—Known only from a single composite sample from the lower third of the exposed section of the Bear River formation at Shell Hollow, 7 miles north of Evanston, Wyoming.

Types.—Univ. Missouri, holotype 0-1099-1 paratypes 0-1205-4.

EXPLANATION OF PLATE 80
All figures ×56

All specimens in University of Missouri collections.
FIGS. *1–6*—*Looneyella monticula* (Jones), (*1*) ventral, 0-1098-3 (*2*) left valve 0-1098-2 (*3*) dorsal, 0-1098-1 (*5*) interior of right valve, 0-1098-5 (*6*) interior of left valve, 0-1098-4
7–9—*Looneyella quadrispina* Peck, n sp., right valve, ventral, and dorsal views of the holotype, 0-1099-1.



Peck, Cretaceous ostracode *Looneyella*

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ONTOGENIES OF THREE GARDEN CITY (EARLY ORDOVICIAN) TRILOBITES

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ABSTRACT—Silicified trilobites from the Garden City formation of northeastern Utah reveal the existence of a new, subovoid, rigid, enrolled type of protaspid, bearing three pairs of supramarginal spines. The examples presented belong to one or both of two *Apatokephalus*-like species. They are trilobed, but lack the normal furrows of the "proto"-glabellar portion of the axis. None of the spine-pairs develops into the genal spines. Protaspid facial sutures differ in no essential detail from those of meraspid and more mature stages.

The ontogeny of the species, *Pseudocybele nasuta* Ross, throws doubt on the theory of anaprotaspid diagonal segmentation insofar as proparian trilobites are concerned; it suggests the existence of a transverse preglabellar segment in the protaspids and shows that the facial sutures are essentially proparian even in the smallest specimens.

The pygidial development of *Macropyge gladiator* Ross indicates that the metaprotaspid pygidium acquires eight segments plus a terminal telson, firmly welded together. During the meraspid period segments are shed successively forward into the thorax, leaving only the telson as the holaspid pygidium, posterior to a thorax of eight articulated segments.

INTRODUCTION

SINCE completion of the initial stage of study of the silicified trilobites of the Garden City formation in northeastern Utah (Ross, 1949 and 1951) work has been continued with a mind to securing more detailed information about the ontogenetic development of as many species as possible. Unfortunately complete silicified specimens larger than those of the protaspid stages are so rare as to be practically non-existent; our knowledge of the development of thoracic segmentation, especially, suffers thereby. Herein facts and inferences are presented concerning ontogenies of three species, one proparian and two opisthoparian.

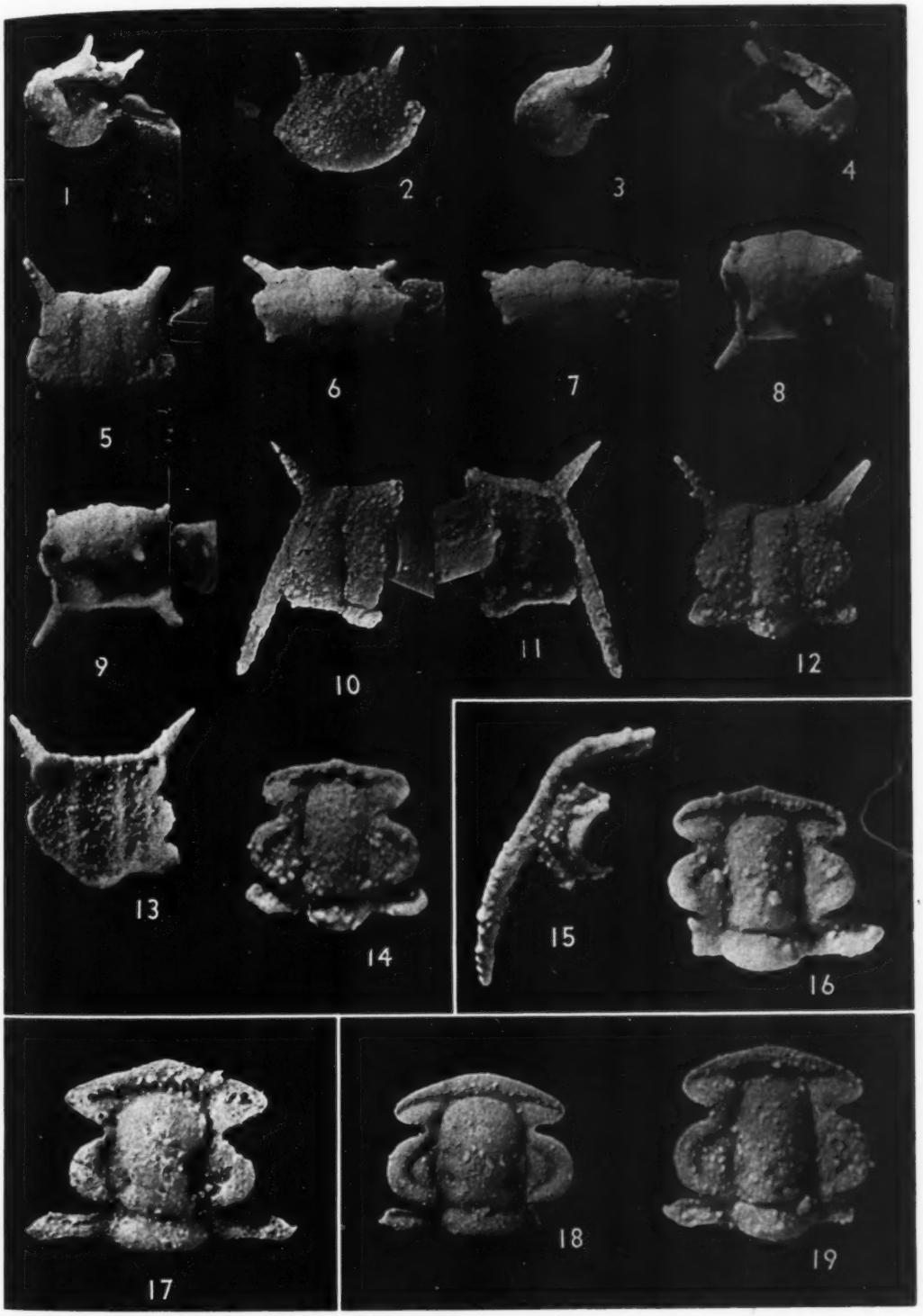
With the kind assistance of the Marsh Fund of the National Academy of Science and of the Research Committee of Wesleyan University additional collections were made during the summer of 1949 to supplement material already on hand; in this collecting the author was assisted in the field by James A. Parkinson and C. Gilbert Bowles. Subsequent preparation of the material has been carried on with the aid of Wesleyan Research Committee grants. To Professor H. B. Whittington and Dr. C. J. Stubblefield I am indebted for many valuable comments on this phase of the study.

EXPLANATION OF PLATE 81

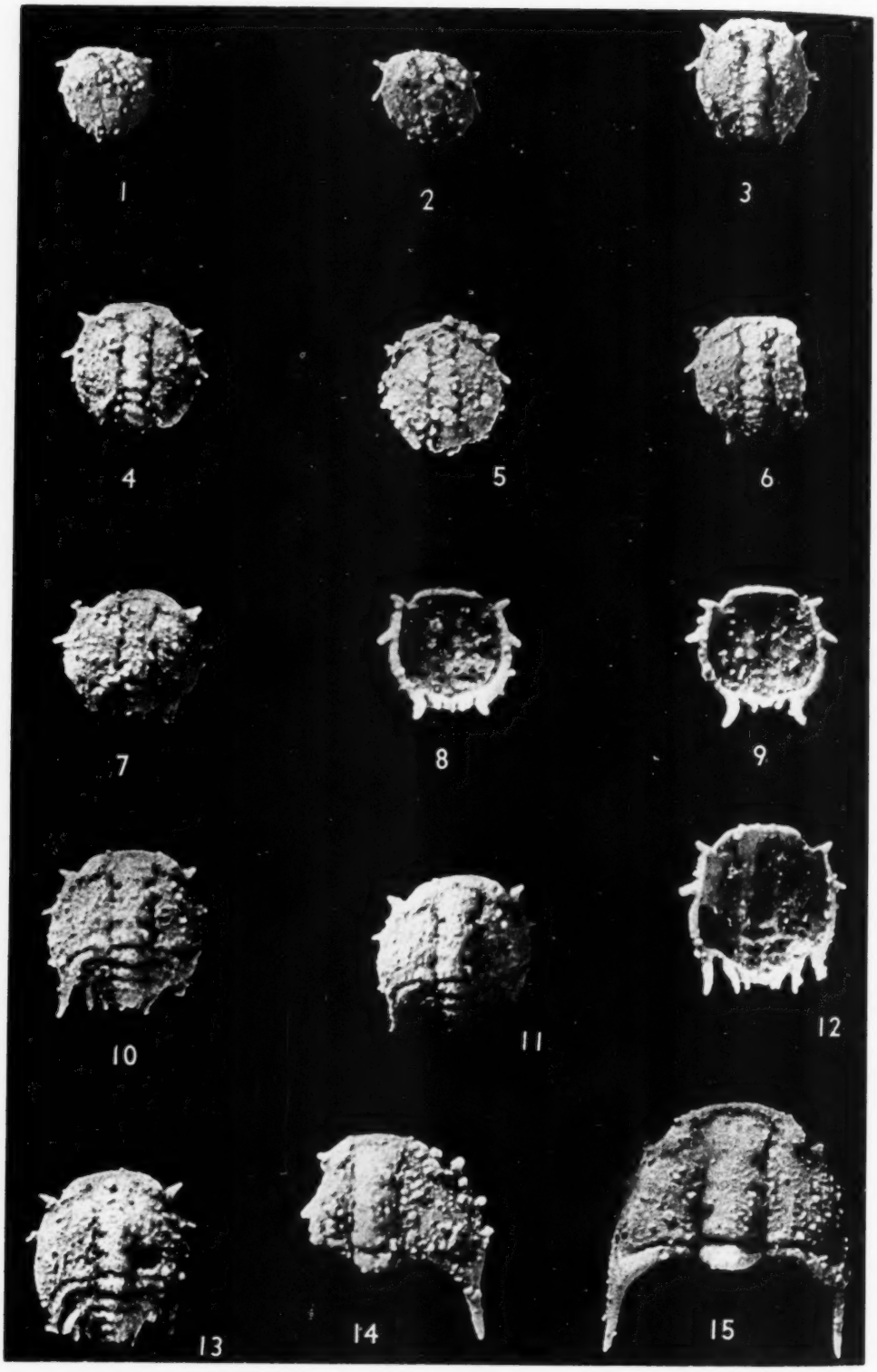
FIGS. *1–14*—*Menoparia genalunata* Ross and/or *Scinocephalus solitecti* Ross. All figures ×30. Specimens mounted on "00" insect pins. *1–3*, anteroventral, dorsal, and lateral views of smallest anaprotaspid, YPM 18384. *4–9*, lateral, dorsal, postero-dorsal, posterior, ventral, and antero-ventral views of metaprotaspid. YPM 18385. *10–11*, dorsal and ventral views of meraspid cranidium with left free cheek still attached. YPM 18386. *12*, meraspid cranidium. YPM 18387. *13*, ventral view of meraspid cranidium, showing facial suture. YPM 18388. *14*, late meraspid cranidium, showing first development of characteristic furrows and loss of anterior spines. YPM 18389. (p. 579)

15–17—*Scinocephalus solitecti* Ross. *15*, free cheek, tentatively assigned, ×30. YPM 18393. *16*, meraspid cranidium, showing long (transverse) posterolateral limb, ×30. YPM 18392. *17*, late meraspid cranidium, essentially holaspid in form, ×18.5. YPM 18391. (p. 581)

18–19—*Menoparia genalunata* Ross. *18*, late meraspid cranidium, showing inception of glabellar furrows and incipient "bulge" of dorsal furrows within compass of palpebral lobes, ×20. YPM 18397. *19*, meraspid cranidium, showing short (transverse) posterolateral limb and lack of glabellar furrows, ×30. YPM 18395. (p. 581)



Ross, Ordovician trilobite ontogenies



Ross, Ordovician trilobite ontogenies

ONTOGENY OF *Menoparia* AND/OR *Scinocephalus*

One of the most striking features of the immature fractions of the Garden City trilobite fauna, especially in the "G" and higher zones (Ross, 1949, pp. 479–481; 1951, pp. 10–28), is the occurrence of numerous subovoid protaspids. These possess a distinct axial lobe with little, if any, evidence of transverse segmentation. All appear to be enrolled, but the degree to which the posterior portion is curled under the rudimentary head region varies. Whether the degree of enrollment is a matter of specific, generic, or family importance is not yet known; it may be controlled only by stage of growth. These protaspids clearly do not belong all to one genus or to one family of trilobite. Furthermore, their occurrence is not limited to strata equivalent in age to the Garden City formation, for they have been discovered and are now being studied by W. R. Evitt and H. B. Whittington from Middle Ordovician beds.

Until recently this author has not been certain that these peculiar little forms were trilobites at all, since attempts to trace them through successive growth stages to associated adults have met with limited success. One series of specimens, collected from low in the "G" zone (Locality 6, Ross, 1949, p. 486; 1951, p. 16), now indicates that some can be assigned with confidence to species of one or both of two *Apatokephalus*-like genera, *Menoparia* or *Scinocephalus*. A quick perusal of plate 81 will give the reader some conception of the sequence of growth stages involved in this discussion.

The two species involved are *Menoparia genalunata* Ross (1951, p. 88, plate 20, figs. 28, 29, 34) and *Scinocephalus solitecti* (Ross 1951, p. 90, plate 20, figs. 25–27, 30–33, 36–38). A study of less and less mature specimens of these two species reveals that they lose their identity in cranidia less than 0.85 mm. in axial length (plate 81, figure 14). Somewhat larger cranidia can be distinguished on the basis of length of posterolateral limbs (compare on plate 81, figures 16 and 17 with figures 18 and 19), although the size of palpebral lobes and shape of palpebral and dorsal furrows which so clearly differentiate the large cranidia of the two species do not apply to those of small size. Furthermore of the smallest separate free cheeks (plate 81, figure 15) none possess the extensive doublure of adults of *S. solitecti*. It therefore appears that the protaspid and some meraspid stages of both species may be so similar that they cannot be separated for practical purposes.

Description of the subovoid protaspids.— (plate 81, figures 1–9.) A typical one of the protaspids in question (plate 81, figures 4–9) is a tightly enrolled individual, possessing a low, but distinct, axial lobe from front to back, and three prominent pairs of spines; the lateral lobes show no trace of segmentation, although in the specimen described here the axis is divided into three faint "rings" at the posterior end (plate 81, figures 6–8).

The anterior portion of the carapace is only gently convex and comprises approximately half its total length. In dorsal view it is subtrapezoidal in shape, being narrowest (0.6 mm.) at the front between the bases of the anterior "horns." From the anterior margin the axis is virtually horizontal for 0.5 mm. before becoming involved in the abrupt ventral and anterior flexure of the posterior part of the shell (plate 81, figure 4). The greatest width of the "head" region (0.77 mm.) is located 0.3 mm. behind the front edge. From the antero-lateral "corners" extend stout spines, 0.27 mm. in length,

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EXPLANATION OF PLATE 82

FIGS. *1–15*—*Pseudocybele nasuta* Ross. Zone "J," locality 13. All figures ×30. *1*, anaprotaspid, showing faintly five axial segments. YPM 18399. *2*, anaprotaspid. YPM 183400. *3–7*, second metaprotaspid stage, dorsal views. Respectively, YPM 18401, 18402, 18403, 18404, 18405. *8–9*, second metaprotaspid stage, ventral views, showing continuous doublure around posterior portion of carapace between anterior spines. Respectively, YPM 18406, 18407. *10–11*, third metaprotaspid stage, same specimen, different lighting. YPM 18408. *12*, third metaprotaspid stage, ventral view. YPM 18409. *13*, fourth metaprotaspid stage. YPM 18410. *14*, small meraspid cranidium. YPM 18411. *15*, meraspid cranidium, showing almost complete reduction of anterior and lateral pairs of spines. YPM 18412. (p. 583)

which diverge markedly. The axis is 0.23 mm. in width at a point 0.5 mm. from its front; anteriorly it tapers very slightly to a rounded end which is just tangent to the anterior margin (actually the facial suture).

At the zone of sharpest flexure the axis is crossed by two furrows which define a "ring" (plate 81, figures 6, 7) 0.12 mm. in sagittal length and 0.16 mm. in transverse width. If the forward part of the carapace including this axial "ring" is compared with a presumably meraspid cranidium (plate 81, figures 12, 13) very striking similarities are noted. The axial ring, itself, appears to be the rudimentary occipital ring, indicating that the forward part of the axis is indeed the glabella. The anterior "horns" are almost identical. Although the dorsal furrows are deeper in the meraspid cranidium, the glabellae of the two stages resemble each other closely; on neither is there any sign of furrows other than the occipital furrow. Both are bluntly rounded in anterior outline, and both are tangent to the front edge of the shell. Here it becomes obvious (because the palpebral lobes are more distinct in the meraspid form) that facial sutures bound the sides and front of the test in both stages, passing beneath the horn bases (plate 81, figures 13, 9). Comparison of the palpebral lobes, however, meets with some difficulty, for where they are almost semicircular flanges in the meraspid cranidium (plate 81, figure 12), they are poorly delimited in the protaspid (plate 81, figure 5). It is reasonable to consider the broad arcs along the facial sutures between arbitrary transverse lines 0.17 and 0.45 millimeters to the rear of the glabella's front as bordering eye surfaces (plate 81, figures 4, 5). The portion of the protaspid facial suture bounding the rudimentary posterolateral limb appears to be that which runs vertically downward to the latitude of the posterior end of the rudimentary occipital ring (plate 81, figures 4, 7).

The protaspid test posterior to the occipital ring curves sharply forward beneath the rudimentary cranidium; it also is trapezoidal in outline tapering to a squared end (plate 81, figures 8, 9), which is 0.29 mm. in width. The margins of this posterior portion are furnished with a very narrow doublure. This doublure appears to have its inception from points directly laterad of the posterior end of the occipital ring. A transverse line through the furrow between the occipital and next ring to the rear passes just in front of the bases of the median pair of spines (plate 81, figure 7) and coincides with the inception of the posterior doublure. This fact suggests that all of the test behind such an arbitrary line belongs to a proto-pygidium including both the median and posterior pairs of spines. The axis in this "pygidial" portion possesses two segments (plate 81, figure 8), the posterior one being the longer and expanding to the rear.

From the foregoing description it may be concluded that this protaspid (plate 81, figures 4–9) belongs to the meta-protaspid period (Størmer, 1942, p. 56) since it appears to be divisible into a basic cranidial and a protopygidial region, the latter not yet discrete. It should be noted that the only evidence of transverse segmentation lies along the axis; if it were not for the close comparison between the presumed cranidial region (plate 81, figure 5) and a known meraspid cranidium (plate 81, figures 12, 13) one might consider the whole specimen to represent an anaprotaspid (Størmer, 1942, p. 56) with four axial rings, of which the anterior one is enormously long. This last consideration hardly seems correct.

Since there is no transverse suture separating the cranidial from the protopygidial parts, the specimen cannot be considered as a meraspid and must belong to the metaprotaspid period, stage 2, there being two axial rings behind the occipital ring.

The smallest protaspids (plate 81, figures 1–3) not only lack any trace of axial rings, but also any definition for the medial parts of the axis itself; it will be noted that the axis is clearly defined at the front by shallow dorsal furrows (plate 81, figure 2), but that these furrows fade completely out in the zone of ventral flexure. Furthermore they diverge markedly from front to rear. From the dorsal side of the zone of flexure around to the bases of the posterior pair of spines there is no sign of the axial lobe whatsoever; between the posterior spines, however, it is possible to make out very faint dorsal furrows which run to the posterior end of the shell. The width of the posterior tip of the

axis is comparable to that at the front.

The question then arises as to the stage and period to which the smallest form belongs. We are unable to tell whether the carapace represents a stage in which only the basic (presumably five) number of anaprotaspid segments is present, whether there were fewer than this number, or whether there were more. Without evidence for axial segments other than the relatively featureless "proto"-glabella this author favors the interpretation that this small specimen is an anaprotaspid.

Since Raw (1925) presented his interpretation of the cephalic spines of the immature stages of *Leptoplastus* interest in these features has been heightened. Raw's interpretation was questioned by Swinnerton (in Raw, 1925, p. 322) on the grounds that such spines are common in the planktonic young of many recent crustaceans. With this and other criticisms Størmer (1942, p. 67) has agreed, but makes the statement that such spines are found only in meraspid stages and are lacking in all known protaspids. This statement we now know is not valid, for not only are three pairs of spines found on the subovoid protaspids here discussed, but also on protaspids of the proparian genera *Protopliomerops* (Ross, 1951, p. 145, pl. 32) and *Pseudocybele* (see below).

In the case of *Menoparia* and/or *Scinocephalus* it is almost certain that the spines have some relation to a planktonic life. In the first place it is inconceivable that the subovoid protaspids could have led a crawling or burrowing existence, since their rigid enrollment would virtually have prevented the use of legs for this type of locomotion. Furthermore, the degree of enrollment in the anaprotaspid (plate 81, figures 1, 3) is such that the hindmost part of the shell (posterior to the posterior spines) is directed almost straight to the rear and is "tucked" far under the head region, the midline virtually completing one revolution of a spiral.

In the second place there is no definite evidence that the paired spines are in any way related to segmentation, especially since there is no evidence of segmentation of the lateral lobes at all. If it is assumed that the posterior pair of spines in the anaprotaspid (plate 81, figures 1, 3) are linked to the occipital or preoccipital segment, one would expect to find these spines located relatively farther forward when two axial segments were added to form the metaprotaspid-2 stage (plate 81, figures 4, 9). Instead one finds that the posterior spines are 0.085 mm. in front of the posterior margin in the anaprotaspid and 0.09 mm. in front in the metaprotaspid despite the fact that the latter is about 1.2 times larger. All three pairs of spines appear to hold their positions relative to the carapace as a whole and irrespective of the number of segments.

The fact that the facial sutures are already developed in both protaspid periods virtually eliminates any possibility that any of the spines became a genal or an intergenal spine. It is, in fact, this author's belief that protaspids will eventually be found with the free cheeks intact and that these may be expected to bear their own genal spines, probably not much different from that borne by one meraspid cranidium (plate 81, figures 10, 11).

The fact that facial sutures are present in both the metaprotaspid and anaprotaspid (?) periods in a fashion which may be considered "normal opisthoparian," shows that the eyes (in at least these protaspids) were lateral from the beginning to the end of the ontogeny, and not initially ventral as Beecher and some other workers have claimed.

Meraspid and holaspid development of Menoparia *and/or* Scinocephalus.—(plate 81, figures 10–19; plate 83, figures 19–22). Unfortunately we have no complete carapaces of species assigned to *Menoparia* and *Scinocephalus*, nor any of the growth stages showing the thoracic development. Allocation of various specimens in the ontogenetic suites to stages is therefore impossible. Some pertinent information can be gleaned from them nevertheless.

The smallest discrete cephala and cranidia (plate 81, figures 10–13) still bear the large anterior "horns" found in the protaspids. The glabella is parallel-sided, bluntly rounded in front and almost tangent to the confluent facial sutures. The palpebral lobes and posterolateral limbs have begun to take on outlines characteristic of full grown cranidia; the occipital furrow is well

incised and extends laterally on the posterolateral limbs. No anterior rim, marginal furrow, or palpebral furrows have formed. The free cheeks are essentially the same in outline as those of the adults (plate 81, figures 10, 11; Ross, 1951, pl. 20, figures 29, 30). The largest of these "horned" cranidia found so far is 0.7 mm. in axial length. They surely represent the earliest meraspid stages of development.

Cranidia 0.8–0.85 mm. in axial length (plate 81, figure 14) have lost the anterior "horns" and have developed a marginal furrow, anterior rim, and palpebral furrows and rims. The obtuse angle at which the facial sutures meet in front has become more evident, although it is actually present in the protaspids (plate 81, figure 8). Cranidia slightly larger than this (0.9–1.0 mm. in length) (plate 81, figures 16, 19) begin to show the first criterion by which it may be possible to distinguish *Menoparia genalunata* from *Scinocephalus solitecti*, that is, the difference in transverse length of the posterolateral limbs, relative to the transverse width of the palpebral lobes. This difference is striking in all larger specimens (plate 81, figures 17 vs. 18, and plate 83, fig. 20; Ross 1951, pl. 20, figure 26).

Both species have discrete dorsal and palpebral furrows in cranidia of the size shown in figures 16 and 19, plate 81, but in more mature specimens of *S. solitecti* either the two furrows have joined or one of them has been lost (plate 81, figure 17; Ross, 1951, pl. 20, figures 26, 32, 38). Adequate specimens are not on hand to determine how this comes about.

In *Menoparia*, on the other hand, the dorsal furrow gradually "bulges" outward within the compass of the palpebral lobe, but remains discrete from the palpebral furrow; this process is readily visualized with aid of figures 18, 19, plate 81, and 20, plate 83. It is this separateness of the furrows that distinguishes *Menoparia* from *Apatokephalus* as well as from *Scinocephalus*.

The remarkable extent of the ventral doublure beneath the free cheeks of adults of *Scinocephalus solitecti* (Ross, 1951, p. 90, pl. 20, figure 30) does not appear in cheeks which fit cephala of a length less than 2.5 mm. Although the cheeks can be separated from those of *Menoparia* on the basis of the post-ocular shape of the ocular platform and the course of the post-ocular facial suture for the cephalic length down to 2.0 mm., it has been impossible to distinguish between them with any assurance in smaller specimens (plate 82, figure 11).

Knowledge of pygidial development of these two species is very incomplete. That the pygidia of the two can be distinguished when less than 0.75 mm. in sagittal length is evidenced from figures 21, and 22, plate 83, but beyond this point no information is as yet available. Of interest, however, are several minute pygidia, which clearly belong to one of the species; these (plate 83, figure 19) possess three to four pairs of dagger-like spines and a relatively enormous, erect axial spine. The specimens are so small and the crest of the axis so dominated by the spine base that it is impossible to be sure of the number of axial rings involved. Although the

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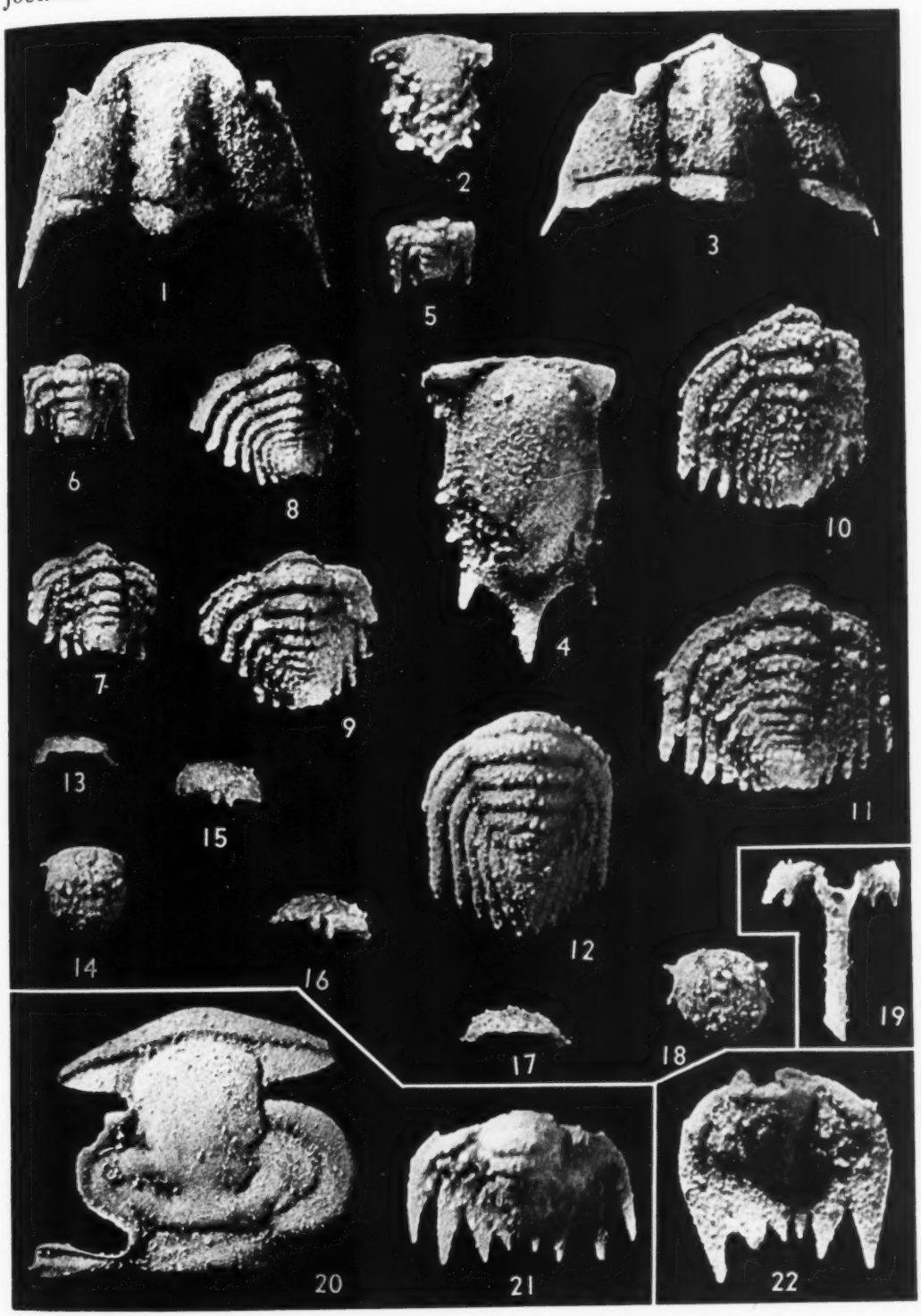
EXPLANATION OF PLATE 83

FIGS. *1–18*—*Pseudocybele nasuta* Ross. Zone "J," locality 13. Figure *3* ×15; others ×30. *1*, meraspid cranidium, showing faint preglabellar pit and lack of definition of palpebral lobes discrete from anterior rim. YPM 18413. *2*, hypostome, smallest identified. YPM 18416. *3*, holaspid cranidium, showing discrete palpebral lobes. YPM 18414. *4*, hypostome with adult proportions. YPM 18415. *5–11*, meraspid pygidia, stages 0 to 5(?). Respectively YPM 18417–18423. *12*, pygidium with holaspid form. YPM 18424. *13–15*, anaprotaspid, anterior, dorsal, and posterior views, showing typical proparian facial suture and close-set posterior spines. YPM 18399. *16–18*, anaprotaspid, slightly larger than above. YPM 18400. (p. 583)

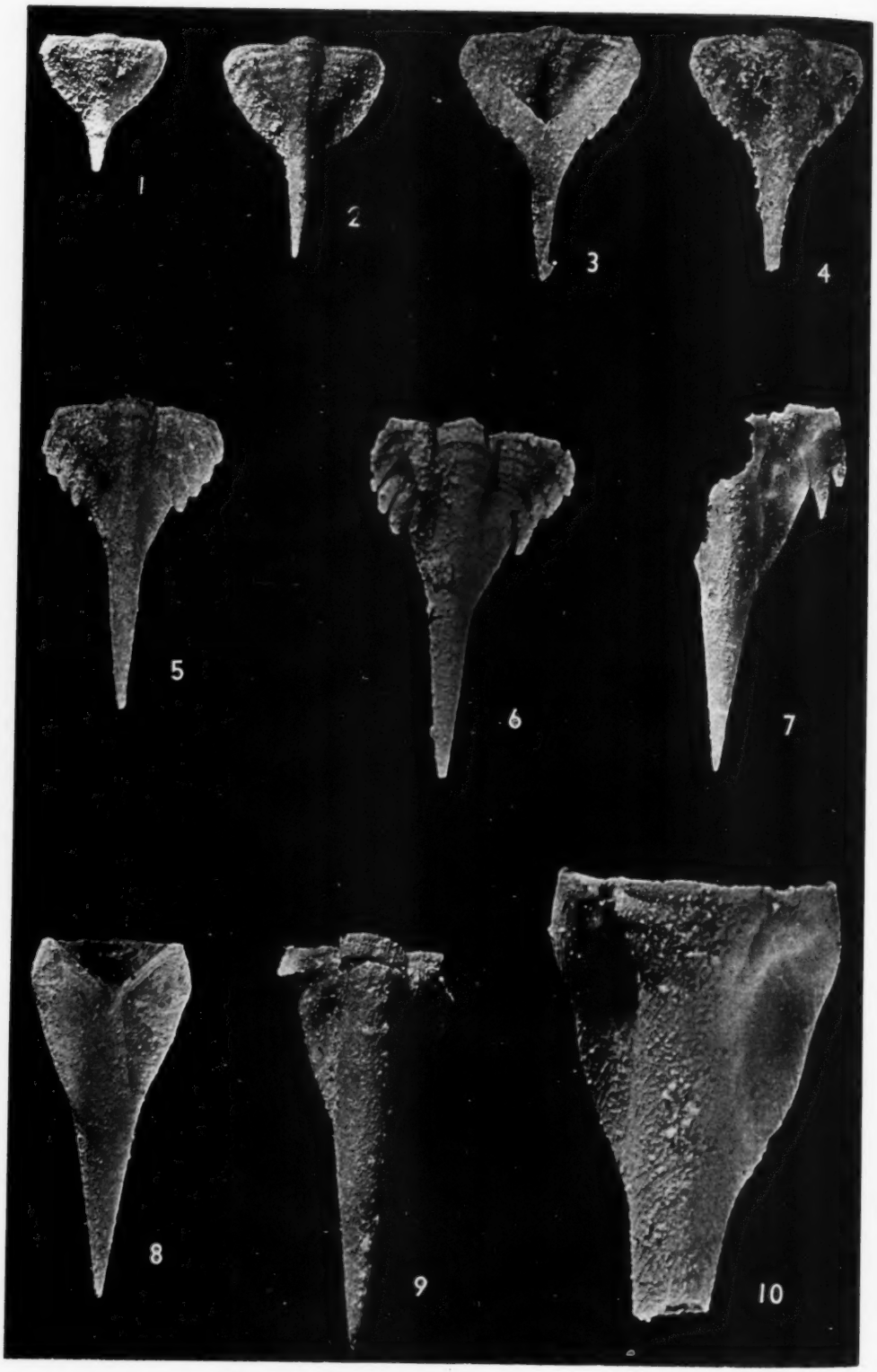
19—*Menoparia genalunata* Ross and/or *Scinocephalus solitecti* Ross. Anterodorsal view of smallest pygidium identified, showing enormous axial spine, ×30. YPM 18390. (p. 581)

20–21—*Menoparia genalunata* Ross. *20*, cranidium, probably holaspid, showing shape of posterolateral limb, ×10.4. YPM 18398. *21*, smallest assignable pygidium, ×30. YPM 18396. (p. 581)

22—*Scinocephalus solitecti* Ross. Smallest pygidium definitely assigned to this species, ×30. YPM 18394. (p. 581)



Ross, Ordovician trilobite ontogenies



Ross, Ordovician trilobite ontogenies

larger pygidia bear no axial spine, a few presumably holaspid segments have been found with such spines; these facts indicate that the spined segment is developed fairly early in the meraspid period, seeming to make its transitory passage through the pygidium into the thorax. When complete holaspid carapaces are discovered, one might expect to find this segment well toward the front of the thorax.

ONTOGENY OF *Pseudocybele nasuta* A PROPARIAN

Plate 82, figs. 1–15; plate 83, figs. 1–18

Very little work has been done on the study of proparian ontogenies starting from the anaprotaspid stages. In fact, in his synthesis of what is known of trilobite development, Størmer (1942, pp. 71–72) mentions only four genera, of which *Dalmanitina* is the best known and that only beginning in the metaprotaspid period. This author (Ross, 1951, pp. 133, 145–150, pl. 32, figs. 2–16) has given an incomplete account of the development of *Protopliomerops superciliosa* from the anaprotaspid through the holaspid stages. To this information can now be added the following on *Pseudocybele nasuta*, a proparian species related closely to *Protopliomerops* and occurring in the "J" zone of the Garden City formation (Ross, 1949, p. 480; 1951, pp. 138–140, pl. 33, figs. 1–14, pl. 34, figs. 13–17, 21–27).

Anaprotaspid stages.—Two minute specimens have been secured of anaprotaspids (plate 83, figs. 13–18; plate 82, figs. 1, 2). Study and photography of these and larger specimens has been handicapped by the coarseness of silicification and adherence of numerous grains of silt, which cannot be removed for fear of destroying the specimens.

The smaller of the two anaprotaspids is 0.45 mm. in axial length; the larger is 0.47 mm. in length. Both are almost circular in outline, strongly convex, and possessed of a distinct axial lobe; both are equipped with three pairs of marginal spines. With great difficulty it is possible to make out five segments in the axis of the smaller form (plate 82, fig. 1) of which the anterior (or first) segment is subcircular in outline (plate 83, fig. 14). Behind the first segment the axis appears constricted at the second segment; the third, fourth, and front of the fifth segment are of the same transverse width as the first, 0.012 mm. The length of the second, third, and fourth segments is approximately 0.005 mm., but that of the fifth is 0.013 mm. Silt particles hide the details of the axis of the larger and of the lateral lobes of both specimens; it is, therefore not possible to be certain that there are no transverse or diagonal grooves on the lateral lobes. The dorsal furrows are much more clearly incised beside the first axial segment than to the rear and appear to include a minute dimple at the "anterior corner" on each side of the first axial segment. These dimples are considered to be rudimentary anterior pits, suggesting that the hypostome had already begun its development.

The first axial segment does not reach the front edge of the carapace which is bordered by an extremely rudimentary transverse rim extending from the base of one anterolateral spine to the other. The front edge of this rim, even in the smaller specimen, is in turn bounded by the facial suture. (plate 83, figs. 13, 17). This facial suture is remarkable in that it bears an extremely close resemblance to the suture of adult specimens of several species of *Protopliomerops* (compare with Ross, 1951, pl. 31, figs. 1, 4; pl. 33, fig. 17). Not only are the positions of the eyes clearly shown by the "up-cut" of the suture, but there is also a suggestion of gentle uparching of the suture near the midline as if to accommodate an epistomal plate. It then becomes obvious that these tiny forms are essentially proparian trilobites almost "from birth", con-

EXPLANATION OF PLATE 84

FIGS. *1–10*—*Macropyge gladiator* Ross. Zone "G," locality 6. All figures ×15. Pygidia. *1*, holaspid-(-7) stage. YPM 18425. *2*, holaspid-(-6) stage YPM 18426. *3–4*, holaspid-(-5) stage, ventral and dorsal views. Respectively, YPM 18427, 18428. *5–6*, holaspid-(-4) stage. Respectively, YPM 18429, 18430. *7*, holaspid-(-2) stage. YPM 18431. *8*, holaspid, but immature pygidium, ventral view. YPM 18432. *9*, holaspid or holaspid-(-1) stage, showing segment being shed forward to thorax. YPM 18433. *10*, holaspid. YPM 18434. (p. 585)

trary to the statement that the facial suture is marginal in proparian protaspids (Størmer, 1942, p. 159).

The three pairs of marginal spines are of interest, since the posterior pair become the genal spines ("intergenal" of Størmer and Raw) of the adult cephalon. In the anaprotaspids (plate 83, figs. 15, 16) this pair is based as close to the midline as is physically possible. Størmer has presented a strong case for considering the "intergenal" spine as part of the preoccipital segment in protaspids of Protoparia and some Opisthoparia; from these he generalizes that the intergenal spines of all trilobites are homologous and that in all cases they belong to the preoccipital segment (1942, p. 158). The evidence at hand does not definitely disprove this contention, but certainly does not corroborate it insofar as the proparian anaprotaspids are concerned. Since the anprotaspids of *P. nasuta* have five segments and since the posterior spines are placed so close together, it is difficult to see how they can avoid being linked to the fifth segment, if to any at all. There is no evidence to indicate that they are linked to the preoccipital segment.

Metaprotaspid stages.—Four metaprotaspid stages are recognized here (plate 82, figs. 3–13), although specimens are available for only the second, third, and fourth. The second stage is illustrated by seven specimens (plate 82, figs. 3–9). Although these differ in relative length of the genal spines and to some slight degree in general outline, all have protopygidia composed of two axial segments of which the anterior one bears spinose pleura. In all the occipital segment is clearly linked with the genal spines; the glabella is composed of five lobes, the anterior one being the largest, the middle three being equal in length, and the occipital ring being the shortest (sagittally).

Specimens of metaprotaspid stage 3 (plate 82, figs. 10–12) differ only in the greater length of the genal spines and in the addition of one more spinose protopygidial segment; in stage 4 (plate 82, fig. 13) a third spinose segment has been added, but the spines of this third (from the front of the protopygidium) segment are so small as to be almost indistinguishable. In this fourth stage the second, third, fourth, and occipital glabellar lobes are of equal sagittal length.

In all the metaprotaspid individuals, regardless of stage, the anterior rim between the bases of the anterior (procranidial) spines is well developed and bounded proximally by a distinct marginal furrow from the front of the glabella. As in the anaprotaspids and early meraspid cranidia there are three pairs of marginal spines, including the genal spines. None of these spine pairs is on the free cheeks and all are located posterior to the eyes; this agrees with species of *Protopliomerops* (Ross, 1951, pp. 145–148, pl. 32, figs. 2–7) and with meraspid cranidia of *Kawina* (still under study). As previously observed by this author (1951, p. 148) the anterior pair of spines cannot be considered in the same light as the procranidial spines of Raw's *Leptoplastus* (1925) since they are located behind the eyes. In the proparians observed in this study they limit the backward course of the facial sutures (plate 82, figs. 8, 9, 12) and appear to have guarded the eyes.

The anterior spines may indeed represent the tips of a transverse pre-glabellar segment as previously suggested in the case of *Protopliomerops* (Ross, 1951, pp. 148–149). Such a segment composed of the anterior rim and free cheeks is not difficult to visualize, especially as the furrow separating the palpebro-ocular ridges or lobes from the rest of the anterior rim does not develop until late in the meraspid or early in the holaspid period (plate 83, fig. 3); this was also found to be the case in *P. superciliosa* (Ross, 1951, p. 133) and separation never becomes complete in *Tesselacauda* (Ross, 1951, pp. 129–131, 141). If this preglabellar segment did exist, we find in it corroborative evidence for Størmer's belief in the existence of "preantennal" segments (1942). However, in these proparian forms it appears evident that such a segment must remain discrete from the frontal lobe of the glabella. It should also be noted that the "pre-antennal segment" in Proparia discussed here includes the eyes, and "palpebral lobes" while in Størmer's interpretation of Protoparia and Opisthoparia it excludes the palpebral lobes (1942, p. 123).

In the metaprotaspid stages of *P. nasuta*

the ventral doublure extends continuously from one anterior spine base around the protopygidium and back to the other spine base (plate 82, figs. 8, 9, 12), indicating that the pygidium is not flexible until after the third metaprotaspid stage is passed. The same condition appears to exist in specimens of the fourth stage (plate 82, fig. 13). The smallest free pygidium found so far (plate 83, fig. 5) possesses a well-developed articulating half-ring, three spinose segments, and a terminal segment; in other words it is structurally the same as the protopygidium of the metaprotaspid-4 stage. From this we must conclude that specimens assigned to this stage should be reassigned to the meraspid-0 stage or that an extra moult without addition of segments, but accompanied by freeing of the protopygidium, has taken place.

Meraspid and holaspid stages.—For lack of complete carapaces little is known of the meraspid development of this species. Successively larger cranidia retain the stumps of the anterior two pairs of marginal spines, an evenly rounded anterior outline, and a sub-semicylindrical glabella until the glabellar length exceeds 1.0 mm. (plate 82, figs. 14, 15; plate 83, fig. 1). By the time the glabellar length has reached 1.7 mm. (plate 83, fig. 3) typical adult features have taken form including the nasute anterior rim, furrow separating the palpebral lobes from the rim, and the inflation and rounding of the front end of the glabella. Whether the change from the meraspid to the holaspid condition takes place along with this change in cephalic features or subsequently cannot be told. With the obvious change the preglabellar median pit becomes strikingly evident, but this is not the time of its inception. Although it has not been observed on all specimens, it can be made out on one or two as early as the metaprotaspid-3 stage (plate 82, fig. 10, 11) and on some of the meraspid cranidia (plate 83, fig. 1). As previously observed (Ross, 1951, pp. 141–143) it appears to be an additional point of muscular attachment for the hypostome, corresponding to the smoothly rounded surface on the midline of its anterior edge (plate 83, fig. 4).

During the meraspid period the number of pygidial segments increases to a minimum of nine, of which the anterior eight are spinose (plate 83, figs. 5–11 in succession). Thereafter, an abrupt change seems to take place during which all but five spinose segments and the elongate terminal segment are apparently lost into the thorax. A similar process has been noted in *Protopliomerops superciliosa* along with the resulting problem of stage designation (Ross, 1951, pp. 145–150).

Pygidial Development of *Macropyge gladiator*
Plate 84, figures 1–10

Macropyge gladiator (Ross, 1951, pp. 122–123, pl. 30, figs. 14, 22) was previously reported from low in the "G" zone of the Garden City formation; as a result of more recent collecting it has become evident that its range extends throughout the entirety of that zone. Among the earlier collected specimens was one articulated thorax with the characteristic, telson-like pygidium attached (Ross, 1951, pl. 30, fig. 22). In the thorax, as in that of the genotype, *M. chermi* Stubblefield (1927, pp. 140–143, pl. 4 fig. 13) there are eight segments.

An ontogenetic series of the pygidia of the Utah species has now been worked out, selected specimens being illustrated on plate 84. This series shows conclusively that there are more segments in the immature than in the mature pygidia.

The three largest specimens illustrated (plate 84, figs. 8–10) show the characteristic "telson," the peculiar shape of the depressed lateral "aprons," and the indistinct division between the axis proper and the telson which distinguishes this species from the genotype.

There is little evidence of transverse segmentation, for the whole pygidium is dominated by the enormous terminal spine; the whole structure is almost completely armored on the ventral side (plate 84, fig. 8). In the axis proper (plate 84, fig. 10) we find evidence for an articulating half-ring, one very short (sagittally) transverse ring, and a rounded "ring" in a shape approaching a half-dome. The construction of the axis is almost identical to that of *Remopleuridiella* (Ross, 1951, pl. 20, fig. 11) and very similar to that in *Menoparia* (Ross, 1951, pl. 20, fig. 34); furthermore, the falcate thoracic

segments are of the same basic type found in both these genera. As a result I have not felt fully confident of the assignment of an asaphid-type cranidium to the species, feeling that it may eventually be discovered that these pygidia and thoracic segments belong to some relative of the "Remopleurid" trilobites.

Successively smaller specimens show that the immature pygidia are composed of additional falcate segments, two more when the over-all length is approximately 3.8 mm. (plate 84, fig. 7), four more when the length is 3.5–3.0 mm. (plate 84, figs. 5,6), five more when the length is approximately 2.5 mm. (plate 84, figs. 3, 4) and six more when the pygidial length has decreased to 2.2 mm. (plate 84, fig. 2). In each of these cases we are referring to the over-all lengths of pygidia but it should be noted that in successively smaller specimens a relatively smaller percent of the total length is devoted to the telsonic spine; it would be more correct, therefore, to compare lengths of the spine in each stage, but because of the great difficulty in determining the division between the axis proper and the spine in the smaller specimens such a comparison is impractical.

It now becomes evident that as many as six segments are attained by the pygidium to be shed later into the thorax. Any question as to whether these segments are firmly part of the pygidium is quickly dispelled by an examination of the ventral doublure (plate 84, fig. 3) which is solid.

From the above sequence one might expect to find even more segments in the smallest pygidia. In most cases it is impossible to make them out (plate 84, fig. 1), the pygidial shield appearing unfurrowed. In one or two specimens I have been able to make out seven segments when they were wetted, but have been unable to present this evidence photographically. It also seems reasonable to suppose that the very smallest pygidia may possess eight additional segments.

The fact that the smaller pygidia may have seven, and possibly eight, segments in addition to those which are retained in the adult, plus the fact that there are only eight thoracic segments in the adult carapace, leads to the conclusion that the meraspid-0 stage of development in this species must be divisible into eight substages, followed by eight full stages in which the segments are passed forward into the thorax one at a time. In other words the full number of thoracic and pygidial segments appears to be gathered into the pygidium before any are loosed into the thorax. How common such a process is amongst other trilobites is, of course, not yet known.

In some species of *Hystricurus*, for instance, (Ross, 1951, p. 51) it clearly does not take place; in these the immature pygidium maintains a set number of segments. Segments marked by distinctive axial spines can be observed in progressively more anterior positions as the over-all size increases. Eventually the spined segment seemingly disappears off the front of the pygidium and correspondingly large free thoracic segments are found associated with identical spines.

On the other hand a process somewhere in between these two seems to apply to the proparian species described above, in which the pygidium attains a greater number of segments than are retained in the adult form, but a lesser number than compose the thorax and pygidium together.

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JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 5, PP. 587–616, PLS. 85–88, 1 FIG., SEPTEMBER 1951

SOME MIDDLE ORDOVICIAN TRILOBITES OF THE FAMILIES CHEIRURIDAE, HARPIDAE AND LICHIDAE

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ABSTRACT—A new subfamily, Heliomerinae, of the trilobite family Cheiruridae, is described. To it are assigned the two genera *Heliomera* Raymond, 1905, and *Heliomeroides* Evitt, n. gen. Generic diagnoses are given. Two new species of *Heliomeroides* are described of which one is designated the genotype. Two other species formerly referred to *Heliomera* are assigned here; one is redescribed, the second discussed. Previously only fragmentary cranidia referable to this genus were known. One of the new species is represented by numerous silicified remains which have permitted a thorough study of the morphology of the test and a partial description and analysis of the ontogeny. The type species of *Heliomera* is described. These five species represent all known members of the subfamily and are compared in summary and tabular form.

A revised generic diagnosis of the harpid genus *Dolichoharpes* Whittington, 1949, is given, along with additions to the description of one species and information on its ontogeny. *Probolichas* Phleger, 1936, (family Lichidae) is considered a subgenus of *Amphilichas* Raymond, 1905, and a new species described. The paper is illustrated, in part, with stereophotographs.

INTRODUCTION

THE present study is based primarily upon silicified trilobite remains recovered by the acid etching of limestone blocks collected from the lower part of the Lincolnshire limestone of lower Middle Ordovician age. All blocks were from the road-cut exposure along the north side of Tumbling Run, a small tributary to the North Branch of the Shenandoah River, about two miles southwest of Strasburg, Shenandoah County, Virginia (Cooper and Cooper, 1946, geologic section No. 10). For purposes of comparison other specimens, not collected by the writer, were borrowed for study and are here described. The major substance of this work, that based on the silicified material, was presented as a dissertation in partial fulfillment of the requirements of the degree of Doctor of Philosophy at the Johns Hopkins University in February, 1950.

The first study of trilobite morphology and ontogeny based on material of this kind was that made by Whittington (1941) of a Trentonian trilobite faunule from Virginia. Treatment of suitable trilobite-bearing raw material by etching yields a large quantity of unusually well preserved remains completely freed from the matrix and including many of the younger growth stages not ordinarily encountered with usual means of preparation. The ability to observe the interior surfaces of the elements of the dorsal shield permits the examination of the loci of muscle attachment and other internal structures rarely seen. For much fundamental information on these we are indebted to Öpik (1937) and his interpretations of the exceptionally preserved calcareous fossils of the Estonian Ordovician sequence.

In the descriptions I have used the terminology of Warburg (1925) as a basis. The specialized terminology of Warburg (1939) is used in describing the lichid subgenus *Amphilichas* (*Probolichas*) and that of Whittington (1949, 1950) for the harpid genus *Dolichoharpes*. "Glabella" is used in the sense of Ross (1948) to include the occipital ring. Lateral glabellar lobes and furrows are numbered from back to front. "Ocular platform" is used in the sense of Howell, et al. (1947). "Midlength" is the length along the midline. In referring to dimensions or proportions, certain abbreviations suggested by Richter (1940, pp. 16–17) are used : "sag." in parentheses indicates measurement along the sagittal or midline, "ex-sag." a direction parallel to this but not along the midline, and "tr.," a direction transverse to the midline.

Many of the trilobite parts here de-

scribed are quite convex. Because of the steep inclination of certain of these parts in life, a view of the test from a morphologically dorsal or ventral direction results in a marked foreshortening of important features. "Full surface views," i.e. views perpendicular to the largest surface area, are most advantageous for description. They are not necessarily dorsal or ventral morphologically, although these latter terms have been very generally used for them (see comments by Warburg, 1939, p. 6). In the present paper the adjective "true" is used to indicate a morphologic direction with reference to the assumed position of the animal in life; e.g. "true dorsal view." Where directional terms such as "dorsal" and "ventral" are used unmodified, a full surface view is implied.

Holotypes of all new species herein described and all figured specimens, unless otherwise indicated, are in the United States National Museum.

It is a pleasure for the writer to express his grateful thanks to the persons listed below: to Harold E. Vokes, The Johns Hopkins University, for assistance and guidance, especially in regard to the taxonomic problem involving *Cheirurus sol* Billings; to G. Arthur Cooper, the United States National Museum, for much encouragement and assistance and for the loan of the holotype of *Heliomeroides treta* Evitt, n.sp.; to J. Marvin Weller, Walker Museum, The University of Chicago, for loan of the holotype of *Heliomeroides raymondi* (Bradley); to Alice E. Wilson, the Geological Survey of Canada, for the preparation of molds and casts of the holotype of *Heliomera sol* (Billings); to Carl O. Dunbar, Yale Peabody Museum, for his efforts to locate Raymond's specimen of *Heliomeroides* sp.; to Harry B. Whittington, Harvard University, for original information on the holotype of *Dolichoharpes reticulata* Whittington.

SYSTEMATIC DESCRIPTIONS

Family CHEIRURIDAE Hawle & Corda, 1847

Subfamily HELIOMERINAE Evitt, n. subf.

A new subfamily is required for the reception of the genera *Heliomera* Raymond, 1905, and *Heliomeroides* Evitt, n.gen.

Subfamily characteristics.—Cephalon with large cranidium and long and narrow free cheeks. Glabella comprising most of the cranidium, wider than long and not strongly convex, with large occipital ring and three pairs of glabellar furrows in more or less radial orientation. Hypostoma rectangular, wider than long, with very wide border, distinct middle body, feebly developed anterior wings. Number of thoracic segments unknown; inner part of thoracic pleurae very narrow (tr.), outer part a long hollow projection; pleurae without furrows or pits. Pygidial segments few in number; poorly differentiated from the thoracic ones.

Known genera.—*Heliomera* Raymond, 1905; *Heliomeroides* Evitt, n. gen.

Known range and distribution.—Middle and Upper Ordovician, central and eastern North America.

Taxonomic problem.—A taxonomic problem is involved in the application of generic and specific names to the known representatives of the subfamily Heliomerinae. The complicating circumstances are outlined below.

In 1865 E. Billings described *Cheirurus sol* from the Newfoundland Chazyan. His specimen (a single glabella) is in the collection of the Geological Survey of Canada and the writer has studied plaster casts made from a rubber mold of the original. Billings' written description (1865, p. 288) is in complete agreement with the specimen but his illustration, a single line drawing, suggests certain features (principally an isolated median glabellar lobe) not actually possessed by the specimen.

Some forty years later, P. E. Raymond found in the New York Chazyan the glabella of a trilobite which he considered to be conspecific with *Cheirurus sol* Billings. For this he (Raymond, 1905) proposed the new subgeneric name *Heliomera*. Toward the end of his paper, which deals with numerous trilobites, appears the heading "*Heliomera* subgen. nov.," followed by the specific description of "*Heliomera sol* (Billings)", listing *Cheirurus sol* Billings as a synonym with the exact reference to Billings' 1865 description. In his description Raymond specifically mentions the isolated central lobe of the glabella and closes by saying: "For trilobites with this type of glabellar

structure the subgeneric name *Heliomera* is suggested." He also states that his material is "from the Raphistoma layers in the upper part of the lower Chazy at Chazy, New York" and that "the type is in the Yale University Museum."

Raymond's first error, though a minor one, was the reference to his New York specimen as "the type." According to his understanding of *Heliomera sol* (Billings) this was an incorrect statement which he corrected later by stating (Raymond, 1910b, p. 78): "The plesiotype is in the Museum of Yale University. The original specimens described by Billings were from Table Head and near Portland Creek, Newfoundland." (The explanation of his reference to two specimens will be found in this paper in the discussion of *Heliomera sol.*)

These discussions, viz. those of Billings in 1865 and of Raymond in 1905 and 1910, establish the nomenclatorial fact, under Article 30, Rule (c) of the Règles Internationales de la Nomenclature Zoologique, that *Cheirurus sol* Billings is the genotype of *Heliomera* Raymond, 1905, by monotypy.

The taxonomic problem arises when we consider the conclusion which one must reach after comparing casts of Billings' specimen with Raymond's description and figures, namely, that Raymond never saw the actual specimen of *Cheirurus sol* Billings from Newfoundland, but based the identification of his New York specimen on the inaccurate and misleading illustration in Billings' paper. If this conclusion is correct, then Raymond's second error is understandable, for, by coincidence, the two lines of hachures on Billings' sketch, which were intended to indicate that the median portion of the glabella possesses a slight independent convexity, occupy precisely the same positions as the two longitudinal furrows which distinctly isolate a median glabellar lobe in Raymond's specimen. From the drawing alone the lines of hachures easily could be interpreted as furrows, but the replicas of Billings' specimen (and the photographs of them on plate 85) show conclusively that no furrows exist here.

Thus, Raymond's identification of his specimen with *Cheirurus sol* Billings was incorrect. The two are not conspecific and in my judgment are not even congeneric (choosing as I do to elevate the name *Heliomera* to generic rank).

Opinions 65 and 168 of the International Commission of Zoological Nomenclature suggest that where there is evidence that an author established a genus on a misidentified species, the case should be submitted to the Commission. These opinions would seem to apply in the present case. However, at the 1948 meeting of the Commission in Paris it was decided to reword Article 30, Rule (g) of the Règles to make it clear that "a type selection is not invalidated where the author making the selection misidentified the species which he so selected" (Bull. Zool. Nomen., 1950, vol. 3, p. 83). The tenor of this revision is counter to that of opinions 65 and 168. In view of this contradiction and other considerations which suggest a nomenclatorially sound course I have chosen not to submit this case to the Commission at the present time.

My conclusions and actions are here set forth and justified:

1. I recognize *Cheirurus sol* Billings as genotype of *Heliomera* Raymond, 1905, by monotypy. Article 30, Rule (c) of the Règles affords the technical basis for this. However, as will be pointed out, certain illogical conditions result in the present case by the strict application of this rule.

2. Raymond's species stands without a generic or a trivial name, since *Heliomera* applies to Billings' specimen, not Raymond's and Raymond simply used the trivial name *sol*, but in no sense "proposed" it as new along with his proposal of the name *Heliomera*.

3. I refer Raymond's species, along with three other species, to a new genus *Heliomeroides* Evitt, but I suggest no trivial name for Raymond's material. His specimen, which he states is in the Museum of Yale University, cannot be found (C. O. Dunbar, personal communication, 1950). His published description is not sufficiently complete to permit a satisfactory comparison with congeneric species, and his illustrations are poor. Therefore, it seems unwise to name this species which cannot adequately be defined. I prefer to let this await either the recovery of the lost specimen or the finding of other material.

4. Raymond's material consisted of one incomplete cranidium only. In view of this and in view of the facts stated in the preceding paragraph, it seems equally unwise to use this specimen as the basis for a new genus, even if it were to be given a trivial name and even though it was first described some forty-five years ago. Two of the other three species congeneric with Raymond's (one new, the second already described) are inappropriate as genotypes because each is known only from one incomplete cranidium. On the other hand, the fourth species (new) is represented by multiple examples of all parts of the test recovered by etching the lower Lincolnshire limestone. It, therefore, is the most desirable choice for genotype and I designate it, *Heliomeroides teres* Evitt, the genotype of *Heliomeroides*.

The course of action which I have elected to follow is not ideal and care should be taken to point out its unfortunate consequences. As a result, Raymond's written description (1905, p. 381) which includes as an integral part the proposal of the name *Heliomera*, does not apply to *Heliomera* at all, but to a nameless species of the new genus *Heliomeroides* Evitt. This single paragraph is at one and the same time the nomenclatorial basis for the generic name *Heliomera* and the taxonomic description of a species belonging to another genus. This is illogical but unavoidable. It must be emphasized that the sole part of Raymond's description which actually applies to *Heliomera*, i.e. to *Heliomera sol* (Billings) which is the only known species, is the generic name. The description itself does not apply. Even Raymond's statement: "For trilobites with this type of glabellar structure the subgeneric name *Heliomera* is suggested," thus become meaningless.

Relationships of the Heliomerinae.—The large size and the gentle convexity of the glabella and the tendency toward radial arrangement of the glabellar furrows set the known species of the two genera referred to this new subfamily apart from the rest of the members of the family Cheiruridae. But there are other features characteristic of these genera and some discussion of these is necessary to understand their positions within the subfamily and to indicate its relationships to other cheirurid groups.

Heliomera is probably the geologically older genus, though the precise age of the rocks in which it has been found is uncertain. Structurally it seems to be transitional between what we might consider loosely as a "normal" cheirurid trilobite and the extreme conditions which are met with in *Heliomeroides*. These displacements from the "normal" will be described before proceeding to detailed descriptions of the species. They are not unique but are exhibited by other forms, some closely related to the Heliomerinae, some not.

1. A lateral expansion and flattening of the glabella. In *Pseudosphaerexochus* and *Nieszkowskia* is seen a glabellar expansion which is both lateral and dorsal; in the Heliomerinae the lateral expansion is extreme, while the dorsal surface is flattened. This dorsal flattening is suggested by some species of *Pliomera*, e.g. *P. fischeri* (Eichwald). In the Heliomerinae this flattening does not seem to be demonstrably a phylogenetic trend since it is at a maximum in *Heliomeroides teres* Evitt, n.sp., which is neither the geologically oldest nor youngest species of the group. The lateral expansion is a subfamily characteristic which seems to show relatively little variation.

2. Radial arrangement of the lateral glabellar furrows. This feature, which led to the names "heliomera" and "sol," results primarily from the lateral glabellar expansion. A tendency toward this design is apparent in *Pliomera*, *Pseudosphaerexochus* and *Holia* as compared with *Ceraurus*, for example.

3. Reduction of the forward parts of the cranidium to a narrow band along the glabella. This is like the structure in *Pseudosphaerexochus*, *Sphaerexochus* and several other cheirurid genera. In *Heliomeroides* the disappearance of the evidences of the boundaries between the primitively distinct parts of this band (border, ocular ridge, etc.) is complete, so that they cannot be differentiated (at least in the youngest forms found so far).

4. Isolation of a median glabellar lobe. This seems to have been a distinctively phylogenetic trend in the adults of the known species. In *Heliomera sol* the median lobe possesses a slight independent convexity, but there is no suggestion of a posterior prolongation of the inner ends of the lateral glabellar furrows to join the ones be-

hind. This feature develops in *Heliomeroides*. In *H. teres*, of Middle Ordovician age, the inner ends of the furrows are joined one to another and the median glabellar lobe is isolated, but the longitudinal furrow formed by these junctions is not so deep as the third furrow proper and has an irregular course. The extreme is reached in *H. raymondi*, of Cincinnatian age, where the longitudinal furrows are nearly equal in depth to the lateral glabellar furrows and actually wider than they. They participate in an unbroken depression extending from the anterior marginal furrow to the occipital furrow and the median lobe is completely and conspicuously isolated. These structures are developed to an intermediate extent in *H. treta*, which is also intermediate in geologic age.

It should be noted that in the youngest individual of *H. teres* the degree of development of these longitudinal furrows closely approaches that shown by the specimen of *H. raymondi*. The latter is somewhat more mature than the former but is surely not adult. This suggests that either, a) there may be here an example of neotony, or, b) the longitudinal furrows in *H. raymondi* may become less marked with increasing maturity.

The isolated median lobe, though in striking contrast to described species of *Pseudosphaerexochus* and *Pliomera* (to which there seem to be other similarities in this subfamily), is a feature known not only in several species of other cheirurid genera (e.g. *Ceraurus ruedemanni* Raymond, *Areia bohemica* and *A. fritschi* Barrande) but also in encrinurids (*Cybeloides* Slocum) and phacopids (certain species of the Synphorinae). Raymond (1905) was the first to point out that this lobe results from the junction of the posteriorly deflected proximal parts of the glabellar furrows. In many cheirurids it is common for the proximal part of the first glabellar furrow to bend backward and join the occipital furrow, thus isolating the basal lobes from the median portion of the glabella. A similar development of the other two lateral furrows would not seem a very extreme modification, though in company with other features, the effect on the pattern of the cranidium in *Heliomeroides* is particularly impressive. Indeed, from a structural standpoint, it would seem preferable to consider this development as an isolation of the lateral lobes, rather than an isolation of the median lobe, However, the description is rendered more lucid by doing the reverse.

The resemblance of the median lobe in *Heliomeroides* to that in lichid trilobites, mentioned by Raymond, cannot imply close relation, but development from a similar pattern of lobation might have commenced the lichid line among opisthoparian trilobites.

5. A median structure on the frontal lobe. The frontal lobe in all known species of *Heliomeroides* (but not in *Heliomera sol*) is marked by a median structure probably associated with muscle attachment on the interior surface of the test. This is developed as an elongate area devoid of ornamental granules in *H. teres*, as a row of four distinct pits in *H. treta*, and as a furrow-like depression in *H. raymondi* and in Raymond's unnamed species. Raymond remarks that in his specimen this furrow is reminiscent of *Pliomera*. In *H. raymondi* it is not so deep. The pits in *H. treta* recall median pits encountered in *Cybeloides* and other encrinurids. These observations suggest that the explanation of this structure lies in a morphological feature common to many trilobites, rather than suggesting close relationship between any specific groups.

Note: The following remarks are based on *Heliomeroides teres* only.

6. Reduction in size of the cheek lobe. This, also, is a result of the lateral glabellar expansion. It is more extreme than in *Pseudosphaerexochus*, but only slightly greater than in *Sphaerexochus*. The configuration of the free cheek in *Heliomeroides* is particularly affected by the very wide border (cf. *Pliomera fischeri*), much reduced ocular platform and posterior position of the eye.

7. Absence of furrow or punctae on thoracic pleurae. In this respect the thoracic segments differ from most cheirurids, but *Sphaerexochus* is a similar exception.

8. Miscellaneous. Another similarity to *Nieszkowskia* is in the pygidium with its four backward directed pleural projections from the two well developed segments. The articulation is strongly suggestive of that in a new subgenus of *Nieszkowskia* represented in the same material and to be described in a subsequent paper. The in-

terior surfaces of the cranidium, thorax and pygidium are like those in this same new subgenus and in *Sphaerexochus* in lacking distinct appendifers. A rostrum is present (conclusively indicated by the shape of the adjoining parts of the cephalon, though not yet found) as in other cheirurids.

9. Hypostoma of distinctive design. This plate is not the least cheirurid in appearance, unless it be in the general conformation of the middle body with its middle furrows. The adult hypostomas of the cheirurids as a group are fairly well known. Resemblances within genera are strong, and within the family the younger hypostomas show unmistakably similar basic designs. All have one thing in common: the pronounced development of anterior wings. But, in *Heliomeroides teres*, the adult hypostoma is completely distinct from any other adult cheirurid hypostoma in shape and in lacking typical anterior wings (the latter feature consonant, however, with the absence of anterior pits on the cranidium), and the youngest hypostoma found shows no obvious similarity to the smaller hypostomas of other cheirurids or to any readily conceivable "average cheirurid type."

Ever since the days of Novak and Barrande evidence gradually has been accumulating that the trilobite hypostoma is a particularly reliable portion of the test for indicating generic and supergeneric relationships. This has been demonstrated in many cases, but it is not without exception. For example: *Staurocephalus*, whether it be a cheirurid or an encrinurid, has a hypostoma not typical of either family, and some species until now all referred to the single genus *Remopleurides* have vastly different hypostomas.

To summarize this section: The structural modifications which are combined (sometimes in a rather extreme degree) to distinguish the subfamily Heliomerinae fall into two groups. In the first are those features which are represented individually in well known members of the family Cheiruridae (and the Pliomeridae to a lesser extent) and argue strongly for placing the subfamily here. In the second are features found erratically among other trilobites, apparently representing specializations acquired by members of unrelated groups and thus having no major taxonomic significance. The most non-cheirurid feature of the subfamily, the design of the hypostoma of *Heliomeroides teres*, must be considered an exception to the typical cheirurid pattern.

Note: The high quality of the preservation and the availability of numerous specimens of all the skeletal parts (except the rostrum) have permitted an exhaustive discussion of *Heliomeroides teres*. This should firmly establish the general characteristics of the genus which are shared by the other species now, or in the future, referred to it, as well as indicate the specific characteristics of this species. In describing the other two known species of the genus specimens of which have been available to the writer, it has seemed sufficient to concentrate on those features which show marked specific variation. In the case of Raymond's species of *Heliomeroides* whose only known speci.

EXPLANATION OF PLATE 85

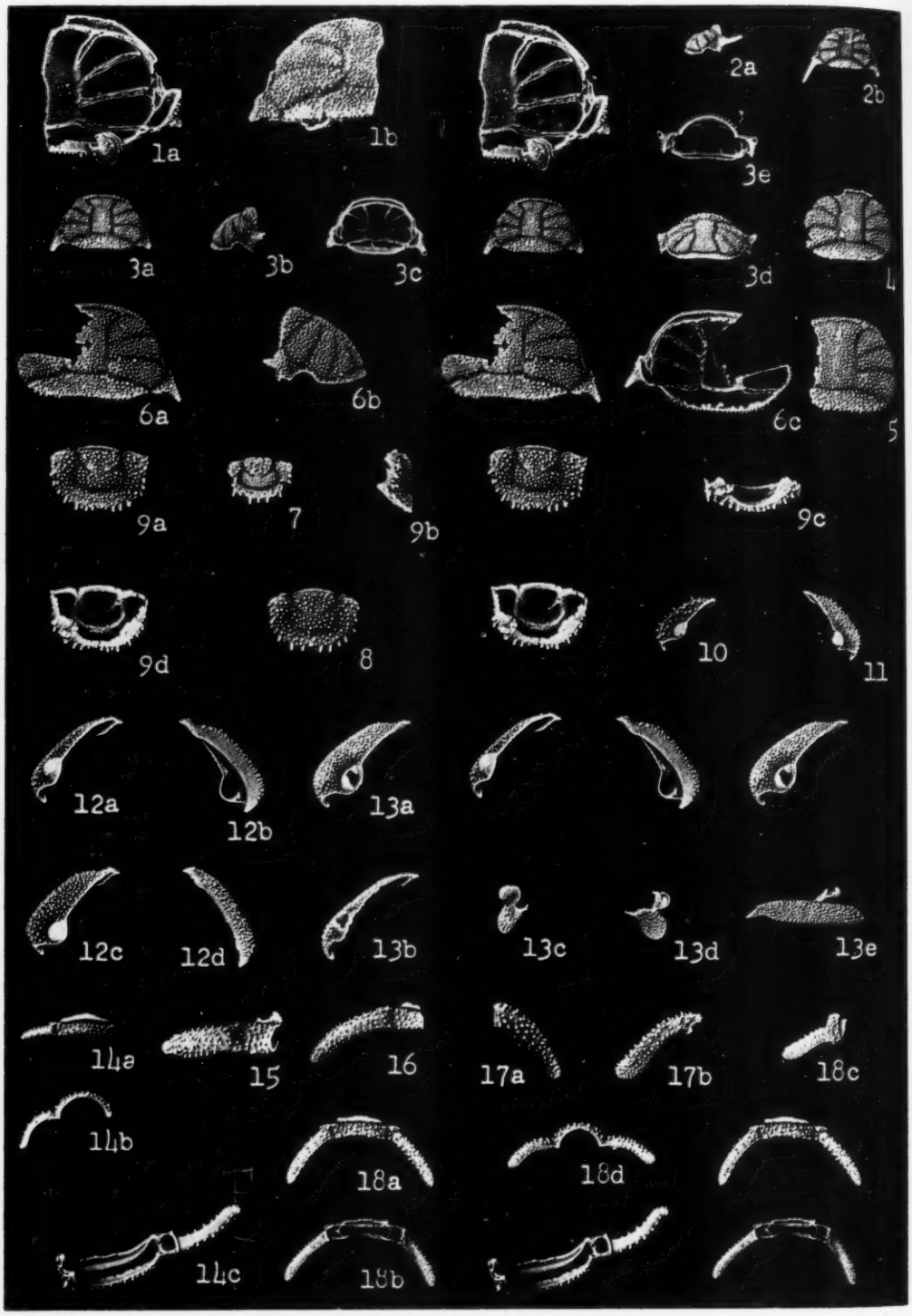
FIGS. *1–5*—*Heliomeroides teres* Evitt, n. sp., the holotype cranidium, USNM 116294. *1*, dorsal stereogram, ×3.2; *2–3*, left lateral and true anterior views, ×3.2; *4–5*, oblique view and low anterior profile, ×3.5. (p. 594)

6–14—*Heliomeroides raymondi* (Bradley), the holotype cranidium, Walker Mus. 20692; plastotype, USNM 67351; all figures ×10. *6*, dorsal stereogram; *7–8*, right and left lateral views; *9*, true dorsal view; *10*, true anterior view; *11*, low anterior profile; *12–14*, three oblique views. (p. 600)

15–23—*Heliomeroides treta* Evitt, n. sp., the holotype cranidium, USNM 116293; all figures except fig. *23* are ×2. *15*, right lateral view; *16*, dorsal stereogram; *17*, true dorsal view; *18*, low anterior profile; *19*, left lateral view; *20*, true anterior view; *21–22*, two oblique views; *23*, detail of median glabellar lobe showing median row of four pits, ×5. (p. 601)

24–29—*Heliomera sol* (Billings), plaster cast of rubber mold of holotype. Plastotype, USNM 116292; holotype in National Museum of Canada; all figures ×5. *24*, dorsal stereogram; *25*, low anterior profile; *26*, right lateral view; *27*, true anterior view; *28*, true dorsal view; *29*, oblique view. (p. 603)

Evitt, Middle Ordovician trilobites



Evitt, Middle Ordovician trilobites

men cannot be located, the reader is referred to Raymond's description and only a few salient features are mentioned here. The specific description of *Heliomera sol* (Billings) is as complete as the quality of the single known specimen warrants.

Genus HELIOMEROIDES Evitt, n. gen.

Generic diagnosis.—Cranidium much wider than long and completely dominated by the laterally expanded elliptical glabella of low convexity; lateral glabellar furrows long and impressed, the three pairs and the distal portions of the occipital furrow arranged radially with inner ends of the lateral furrows bent backward, those of the second and third joining the ones behind and those of the first joining the occipital furrow, thus isolating a median glabellar lobe with nearly parallel sides posteriorly, expanding at the front. Occipital ring large; occipital furrow with lateral portions directed outward and backward and connected medially by a transverse portion behind the median glabellar lobe. Palpebral lobes narrow and very close to the glabella, opposite second glabellar lobes; connected around the front of the glabella by a narrow band between the facial and rostral sutures and the axial and preglabellar furrows. Cheek lobe long and narrow, steeply sloping, border very wide, produced into a short genal spine. Eye large and bulbous, schizochroal.

Hypostoma subrectangular, wider than long. Middle body with oblique middle furrows and maculae. Lateral and posterior borders wide; anterior margins of lateral borders straight and without typical anterior wings.

Number of thoracic segments unknown. Inner part of pleura very narrow (tr.) forming simply the base of the long, hollow pleural projection which is directed outward and arched downward in anterior segments, backward and nearly horizontal in posterior ones.

Pygidium of two well developed segments (third rudimentary) with two pairs of posteriorly directed pleural projections very similar to those of the thorax. Axis with two axial rings.

No appendifers on interior surfaces. Articulation simple: distinct articulating flanges on adjoining parts of cranidium, thoracic segments and pygidium; no ball and socket articulation along axial furrows; crude point and socket articulation at extremities of flanges.

Genotype.—*Heliomeroides teres* Evitt, n. sp.

EXPLANATION OF PLATE 86

Heliomeroides teres Evitt, n. sp. (p. 594)

FIGS. *1a–b*—the holotype cranidium, USNM 116294, ×3.2. *a*, ventral stereogram; *b*, true dorsal view.
2a–b—cranidium, USNM 116295, ×4.1. *a*, left lateral view; *b*, dorsal view.
3a–e—cranidium, USNM 116296, ×4.1. *a*, dorsal stereogram; *b*, left lateral view; *c*, ventral view; *d*, true anterior view; *e*, true posterior view.
4—cranidium, USNM 116297, ×4.1, dorsal view.
5—cranidium, USNM 116298, ×4.1, dorsal view.
6a–c—cranidium, USNM 116299, ×3.2. *a*, dorsal stereogram; *b*, right lateral view; *c*, ventral view.
7—hypostoma, USNM 116300, ×8, ventral view.
8—hypostoma, USNM 116301, ×7, ventral view.
9a–d—hypostoma, USNM 116302, ×6. *a*, ventral stereogram; *b*, right lateral view; *c*, posterior view; *d*, dorsal stereogram.
10—left free cheek, USNM 116303, ×7, full surface view.
11—right free cheek, USNM 116304, ×4.1, full surface view.
12a–d—left free cheek, USNM 116305, ×4.1. *a*, true dorsal stereogram; *b*, ventral stereogram; *c*, exterior full surface view; *d*, ventral profile.
13a–e—left free cheek, USNM 116306, ×3.2. *a*, exterior full surface stereogram; *b*, true dorsal view; *c–d*, posterior and anterior profiles; *e*, oblique lateral view.
14a–c—thoracic segment, USNM 116307. *a–b*, dorsal and posterior views, ×4.1; *c*, oblique ventral stereogram, ×8.
15—thoracic segment, USNM 116308, ×4.1, dorsal view.
16—thoracic segment, USNM 116309, ×4.1, dorsal view.
17a–b—thoracic segment, USNM 116310, ×4.1, dorsal and anterolateral views.
18a–d—thoracic segment, USNM 116311, ×4.1. *a*, dorsal stereogram; *b*, ventral stereogram; *c*, right lateral view; *d*, posterior view.

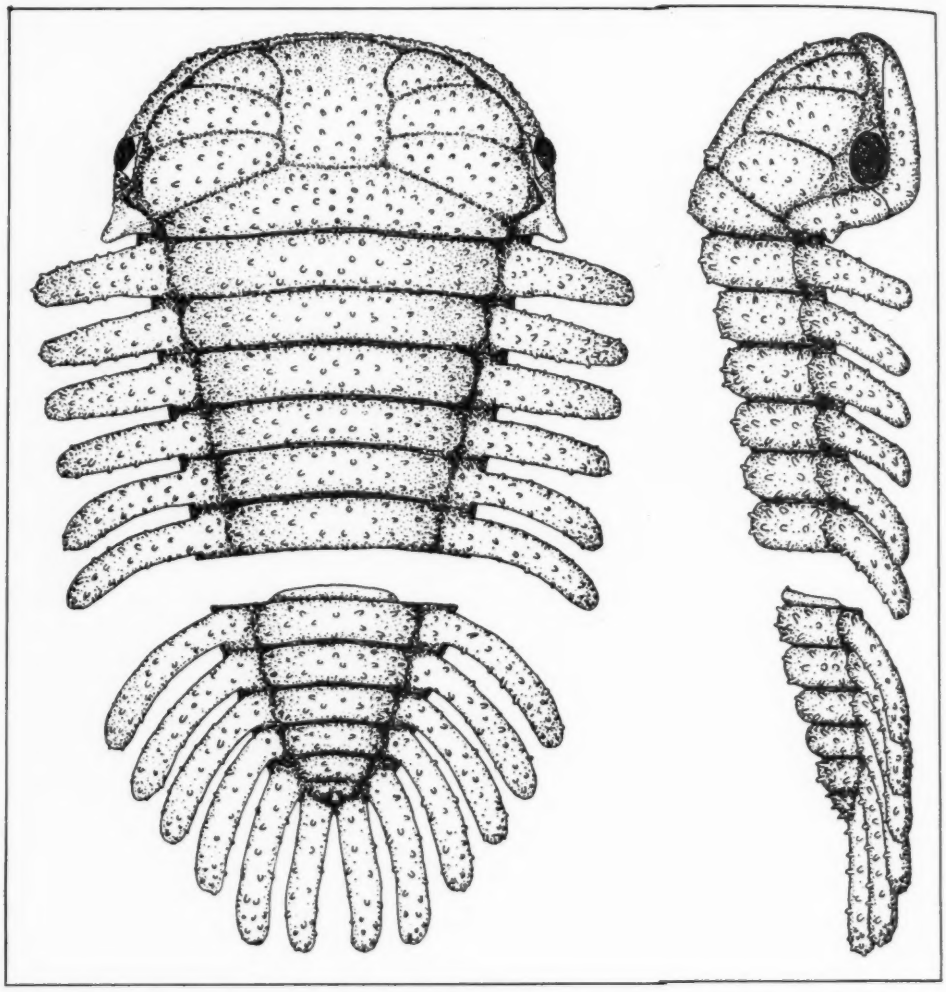


FIG. 1—Reconstructions of *Heliomeroides teres* Evitt, n. gen., n. sp., based upon disarticulated silicified fragments etched from the lower part of the Lincolnshire limestone near Strasburg, Virginia. The reconstructions are about 5× the size indicated by the largest cranidium found.

Other known species.—*Heliomeroides treta* Evitt, n. sp.; *H. raymondi* (Bradley).

Known range and distribution.—Lower Middle-Upper Ordovician of eastern and central North America.

HELIOMEROIDES TERES Evitt, n. sp.
Plate 85, figures 1–5; plate 86, figures 1–18; plate 87, figures 1–4

Horizon and locality.—Lower Lincolnshire limestone, 2 miles southwest of Strasburg, Shenandoah County, Virginia.

Specimens.—Holotype, an incomplete cranidium—USNM 116294; other figured specimens in U. S. National Museum.

Description.—Cranidium. In life position the plane of the generally broad and flat glabella which entirely dominates the cranidium is inclined steeply forward (text-fig. 1) causing an appreciable foreshortening of its features when viewed in true dorsal view. In the following description, to avoid this distortion, the cranidium is oriented in full surface view unless otherwise specifically stated and the directional terms are used with respect to this orientation. Thus "an-

terior" is an axial direction in the plane approximately determined by the axial furrows, though in life this direction is inclined steeply downward. Length and width are measured parallel to this sloping plane.

Cranidium composed almost entirely of the glabella; all other surfaces greatly reduced. Maximum cranidial width across lateral borders just anterior to genal spines 1.8 the midlength.

Glabella a transversely elliptical structural unit, greatest width across basal lobes 1.6 the midlength, over 0.8 the cranidial width; in general gently convex longitudinally and transversely, but with extremities of lateral and frontal lobes sloping steeply into axial and preglabellar furrows.

Occipital ring large, a little more strongly convex transversely than rest of glabella, median portion flattened longitudinally, gently convex near the sides; shortest (sag.) at each axial furrow, nearly coming to a point; longest (sag.) in line with inner ends of glabellar furrows; maximum width about six times maximum length and 0.9 the maximum glabellar width. Lateral portions of posterior margin gently convex posteriorly, median portion straight. Occipital furrow tripartite; each lateral portion deeply impressed and nearly straight behind the basal glabellar lobe, directed inward and forward from axial furrow at about 80 degrees to the midline; median portion much shallower, gently convex posteriorly, length (tr.) one-third the total length of furrow. Rounded posterior edge of ring continued onto narrow occipital doublure with length (sag.) about half that of ring, tapering to disappear before reaching axial furrows.

Axial and preglabellar furows deep; each axial furrow a smooth curve strongly convex outward; preglabellar furrow short, gently convex forward, making an obtuse angle with axial furrow where they meet at distal extremity of third glabellar furrow.

First, second and third glabellar furrows deeply impressed, inclined inward and backward from axial furrow at, respectively, 85, 65 and 25 degrees to the midline, nearly straight and constantly deep for lengths of 0.33, 0.3 and 0.16 the glabellar width. Proximally each furrow is continued by a much shallower portion bent backward and joining the one behind, this part of the first furrow joining the occipital furrow at the junction between its median and lateral portions. There is thus formed a narrow longitudinal depression between the occipital and preglabellar furrows which, in combination with its opposite number, isolates a median glabellar lobe with subparallel sides posteriorly, slightly constricted between inner ends of third glabellar furrows and expanding forward as the frontal lobe with maximum width along preglabellar furrow of 0.38 the maximum glabellar width and with total length of 0.8 the glabellar midlength. Posterior portion of median lobe flat, anterior gently convex but with slight median depression suggesting a short furrow. In some specimens this is developed as a small area devoid of ornament. This area does not extend forward to clearly join the preglabellar furrow. Lateral lobes with very slightly convex lateral portions but steeply rounded along all the bounding furrows; first and second lobes about equal in size and larger than the subtriangular third lobe.

Each palpebral lobe a long narrow rim, set immediately adjacent to axial furrow, its center opposite posterolateral corner of second glabellar lobe; rim gently convex transversely, arched longitudinally; posterior portion demarcated by distinct palpebral furrow which runs into axial furrow anteriorly and posteriorly bends down around corner of eye, running into marginal furrow where cut by facial suture. Anterior end of palpebral lobe opposite middle (along axial furrow) of second glabellar lobe, posterior end a little behind the extended line of first glabellar furrow; distal limit (= facial suture atop the eye) straight in full surface view, inclined inward and forward at 10 degrees to the midline. Anterior branch of facial suture nearly straight, inclined inward and forward at about 45 degrees to the midline to a point which in anterior view lies in line with middle of third glabellar lobe. Here there is a distinct obtuse angle marking junction with rostral suture. Anterior margin in full surface view gently convex forward between the two angles thus formed (separated by 0.6 the maximum glabellar width), in true anterior view rostral suture straight. Anterior border rather wide between the angles and con-

vex longitudinally, narrowing laterally and smoothly continuous with palpebral lobe via a narrow band lying between facial suture and axial furrow. There is no differentiation of the primitive structural units of this band (ocular ridge, marginal furrow, etc.).

The anterior portion of the fixed cheek is a very narrow triangular area along axial furrow; posterior portion steeply sloping, composed mostly of the wide convex border but with a very small area in front of this separated from it by the marginal furrow which extends in a smooth curve from axial furrow at middle of first lobe to posterior corner of eye. Posterior and lateral portions of border of equal length, both very short, joining at genal angle which is produced into a short angular remnant of genal spine. Posterior margin very short (tr.) inclined slightly forward from tip of occipital ring and bearing an articulating flange (see discussion under thorax) extending about half way from axial furrow to base of genal spine. Doublure merely the very narrow turned under edge of border, beginning at flange extremity and continuing under spine. Posterior branch of facial suture directed nearly straight outward from posterior corner of eye, curving a little backward and under after crossing border.

In side view with cranidium oriented in life position, the crests of the median glabellar lobe and occipital ring form a smooth arc, its chord inclined forward at about 50 degrees below the horizontal; in front of this is a short convex curve of the anterior border. Posterior margin of occipital ring about vertical, genal spine in line with this; margin of lateral border of fixed cheek inclined steeply forward at only 25 degrees from vertical; main portion of palpebral lobe about horizontal.

In life position the transverse profile as seen from the rear shows the wide and arched occipital ring, neighbored laterally by short horizontal articulating flange and nearly vertical inner edge of border below the genal spine.

In interior view furrows show as rounded ridges, the longitudinal depressions along posterior part of median lobe weaker than the true furrows. Lateral extremity of occipital ring produced downward into a short angle of shell material which takes part in articulation (see below). There are no distinct appendifers but places of muscle attachment are suggested by broken inner layer of shell material along lateral furrows, lateral portion of occipital furrow, and part of axial furrow between distal extremity of first furrow and middle of third lobe.

Surface ornamentation consists of slender attenuate granules and tubercles closely spaced on most of the surfaces except the depths of the furrows; sparsest toward lateral extremities of occipital ring. Along rounded edges of lateral lobes these are heightened into short spines; elsewhere shorter. Some show on interior surface as small pits.

Free cheek. Very steeply inclined in life position and so oriented that the bulbous eye in part overhangs the border.

In full surface view long and narrow, tapering to a point anteriorly. Maximum length along border 4.5 the width just anterior to the eye, and 2.5 the width through the eye. Cheek composed mostly of the very wide convex border which is rolled under ventrally and continued onto a nearly equally wide doublure. Eye large and bulbous, located atop narrow ocular platform (not visible in full surface view) which rises at almost 90 degrees to the border surface and is separated from this by a moderately deep and rounded marginal furrow. Furrow deepened further into an elongate pit just before reaching each branch of the facial suture. These pits show particularly (as elevations) in interior view. Platform and furrow concentric with eye. Width of ocular platform less than one-third that of border. Center of eye located less than one-third the way forward from posterior extremity.

The upper edge of the point at the anterior extremity is made by the short connective suture, the lower edge by the lateral part of the hypostomal suture borne on the free cheek. The facial and connective sutures meet in an obtuse angle. When the cephalon is completely assembled the apex of this angle coincides with that at the anterolateral corner of the border on the cranidium and the apex of the very acute extremity of the rostrum. This extremity of the free cheek is flexed slightly outward with respect to the rest of the border. In full

surface view the trace of the facial suture is nearly straight from junction with connective suture to the eye, then curves around the inner edge of eye and outward, crossing the border posteriorly, curving sharply backward and under onto the doublure. Outer margin of cheek nearly straight for a short distance from the anterior extremity, making an angle of about 35 degrees with the facial suture; then bending backward, trending in a very gentle outwardly convex curve until encountering an arc (centered a little behind the eye) which carries it to the posterior extremity.

Surface of eye bulb not entirely faceted. Visual surface separated from facial suture by an unfaceted band continuous with the ocular platform and narrowest at what in life position is the highest point of the eye. Thus the visual surface comes to an obtuse point here.

The view (pl. 86, fig. 13e) parallel to the general surface shows the thickness and convexity of the wide border, the elevation of the eye and the nature of the anterior extremity.

Surface ornamented as the cranidium; ocular platform smooth immediately adjacent to visual surface which is schizochroal and bears an estimated 120 facets in the largest specimen.

Hypostoma. Subrectangular; midlength a little over 0.6 the maximum width along hypostomal suture. Anterior margin of three parts: central one in front of middle body gently convex forward and nearly half the total width; each lateral part nearly straight, inclined slightly backward. Posterior margin convex backward.

Middle body with midlength about 0.9 the maximum width across posterior lobe which, in turn, is slightly greater than width at anterior margin. Defined laterally by broad impressions representing lateral marginal furrows; these deepest anteriorly and inclined backward and outward at about 10 degrees to the axis; confluent with deeper posterior marginal furrow which is convex backward. Each middle furrow distinctly impressed, gradually curving onto middle body from anterior extremity of lateral marginal furrow at about 30 degrees to the midline. Proximal extremity midway between anterior margin and posterior marginal furrow, an indistinct macula immediately anterior to end; ends of furrows separated by nearly 0.4 the maximum width of middle body.

Anterior lobe rather strongly convex, sloping steeply to a narrow depressed band along anterior margin and to anterior extremities of middle furrows. Posterior lobe more gently convex.

Lateral border wide, gently convex, flexed dorsad along anterior margin; lateral margin nearly straight, almost parallel to midline, length 0.7 the hypostomal midlength. Posterior border gently convex, narrower than lateral borders, separated from them posterolaterally by gentle depression extending outward from junction between lateral and posterior marginal furrows at about 50 degrees to the midline; posterior margin concentric with posterior marginal furrow.

In interior view, doublure narrow along lateral and posterior margins; nearly parallel to border surface posteriorly, directed more strongly dorsad laterally and extended at each posterolateral corner into a wide posterior wing. From each anterolateral corner a short sharp angle of shell material projects dorsad.

Exterior surface ornamented as the cranidium, except for the smooth band along anterior margin of middle body and smooth middle furrows. Lateral and posterior margins with a few short slender spines. Doublure smooth.

It is to be noted that typical anterior wings are not developed, though the anterior portion of each lateral border seems to be their structural equivalent. Articulating fulcra are nonexistent, a feature compatible with the absence of anterior pits on the cranidium. It seems that the hypostoma must have been attached merely by membranous and muscular connections to the rostrum, free cheeks, and cranidium.

Rostrum. Unknown, but certain of its features can be deduced from study of adjoining parts: wide (tr.) and short (sag.), terminating in acute angles laterally, margin formed by rostral suture nearly straight, hypostomal margin with gently concave central position and straight lateral portions at slight angles to this.

Thorax. Number of thoracic segments

unknown. An anterior segment has wide, arched axial ring and strongly bent down pleura, the inner part exceptionally narrow. Ring defined laterally by distinct but not deeply impressed axial furrow which is slightly convex outward; posterior margin gently convex forward; bounded anteriorly by deep and rounded articulating furrow with wide median portion slightly convex forward and narrower lateral portions directed slightly forward. Axial ring shortest medially and longest (ex-sag.) along each axial furrow, maximum length a little over 0.2 the width. Surface of ring strongly rounded along anterior and posterior boundaries, otherwise gently convex longitudinally. Narrow doublure extending straight forward from posterior margin, longest medially but reaching only half way to ridge representing articulating furrow. Crest of half-ring only slightly above bottom of articulating furrow in side view and considerably below crest of axial ring; length nearly constant, only slightly longer medially and tapering rapidly near axial furrow; midlength 0.67 that of ring behind.

Inner part of pleura very narrow (tr.), width about equal to length and equalling maximum length of axial ring, with straight anterior and posterior margins formed by distinct, parallel articulating flanges, their distal extremities each set off from the strongly convex pleura by a flat supporting surface. Anterior flange slightly longer than posterior one so that, in interior view, the nearly straight and thickened inner edge of the pleural doublure connecting the flange extremities is inclined backward and slightly inward not quite parallel to the midline. Main surface of inner part of pleura convex, constituting simply the base of the tubular pleural projection which is directed slightly backward and arches strongly downward, tapering very slightly and with rounded tip.

Axial ring and inner half of entire pleura ornamented with fine, spine-like tubercles, like the longer ones on cranidium, some arranged in a conspicuous row along anterior and posterior margin; outer half with simple granules more densely spaced. Under surface of pleural projection smooth and flattened. Articulating ring and doublure smooth, articulating furrow smooth for the most part but with a single row of minute granules along each edge.

In oblique interior view (pl. 86) details of the articulation are clear. A sharp projection of shell material extends ventrad at posterolateral extremity of axial ring. This is designed to fit into the slight cavity at distal extremity of articulating furrow of next posterior segment. There is no true ball and socket articulation in the line of the axial furrow. The distal extremity of the anterior flange is extended forward into a short point, while that of the posterior one bears a small socket to receive the point of the next posterior segment. Thus, there are two points of articulation connected by a straight hingeline. This hingeline bears along its surface a fine groove, presumably the line of connecting membrane attachment. There is no clear indication of a device to act as a stop for the enrolling movement.

There are no distinct appendifers. The short rounded ventral projection at the extremity of the articulating furrow is interpreted, not as an appendifer, but as the internal expression of the exterior cavity which receives the articulating point of the next anterior segment.

From front to rear through the thorax the direction and curvature of the outer part of the pleura is considerably modified but other proportions are little changed: the pleurae are progressively bent more backward and curve less strongly downward. A posterior segment is shown in pl. 86, figs. 18a–d. In the anterior segment described above the vertical distance from pleural tip to inner angle between axial ring and articulating flange is slightly greater than that from this point to crest of axial ring. In the posterior segment the former distance is about 0.8 the latter. In dorsal view each pleura is directed outward and backward at about 35 degrees to the midline compared to 80 degrees for the anterior segment. In addition the axial ring is more strongly arched (nearly semicircular in posterior view) and the granulose ornamentation extends over more of the under surface of the pleura near its tip.

Pygidium. Composed of two well developed segments with four backward directed pleural projections like those of the thorax

and a third rudimentary segment without projections.

The largest pygidium is imperfectly preserved, with three of the pleural projections broken off and the fourth distorted. However, from this and smaller specimens it is possible to give a reliable picture of the features and proportions. The basic features of the two well developed pygidial segments are so similar to those of the thoracic segments already described that it is unnecessary to repeat the details of all parts.

Axis convex, with two distinct axial rings, crest of second a little lower and its width only 0.6 that of the first, separated by deep and rounded ring furrow which is slightly convex forward; greatest width of axis 0.6 the pygidial width across anterior articulating flanges. Behind second ring is a deep broadly V-shaped impression, apex forward with a small and nearly isolated elevation within, representing axial portion of a third rudimentary segment. Axial furrows continuous around posterior end of this elevation, but narrowest here; at sides of first two segments inclined inward at about 30 degrees to the midline.

The four pleural projections characterizing the pygidium are very similar to those of the thorax. Each anterior one directed outward and backward at 25 degrees to the midline; posterior ones nearly parallel to midline (broken and deflected in largest specimen illustrated), separated proximally by deep rib furrow crossing the narrow, ill-defined pleural lobe; posterior pair of projections a little more widely separated at bases by narrow, longitudinally convex portion of pleural lobe behind axial portion of third rudimentary segment. Anterior margin of pygidium like that of thoracic segments.

In interior view the segments are united below bases of pleural projections by a high convex ridge with vertical sides, the inner side being the very narrow doublure. Crest of ridge, in side or end view, forms the ventral margin which is composed of two short coplanar lateral portions directed inward and backward at 25 degrees to the midline, smoothly continuous with a much longer (tr.) posterior median portion convex posteriorly and arched slightly dorsad. Anterolaterally this ridge narrows but continues to extremities of articulating flanges (broken in largest specimen). On the interior the furrows show as heavy rounded ridges but are too imperfectly preserved to permit a statement on the evidences of muscle attachment. There are no appendifers.

Maximum width across anterior articulating flanges about 0.8 the length from articulating furrow to tip of pleural projections. When complete the tips of the pleural projections of the first segment probably do not reach quite so far backward as those of the second.

Dorsal ornamentation as on thoracic segments; under sides of pleural projections completely granulated; ventral ridge granulose; narrow doublure smooth.

Development.—A good representation of the younger stages of this species has not yet been found. The protaspis and meraspid pygidia are unknown, and the smallest specimens found of the several parts are essentially similar to the largest. Thus the enumeration of developmental trends is necessarily incomplete.

Cranidium. The smallest cranidium found (pl. 86, fig. 2) has a midlength of 1.45 mm. Only those features in which it significantly differs from the adult are mentioned here. Genal spine long and pointed, 0.5 the cranidial midlength, directed backward and outward at 25 degrees to the midline and, in side view, slightly upward; nearly straight. Lateral portion of occipital furrow, first, second and third glabellar furrows directed outward and, respectively 60 and 85 degrees backward, 80 and 40 degrees forward. Longitudinal furrow formed by inner parts of glabellar furrows straight, parallel to midline and nearly as deeply impressed as the furrows themselves. Glabella widest across posterior portion of second lobes. Occipital ring rather strongly convex, its crest considerably above that of the rest of glabella. General slope of cranidium in side view less than 30 degrees forward below the horizontal.

Developmental trends with increasing size; 1. Reduction of the genal spine to a short angular projection. 2. Forward rotation of the distal extremities of occipital and

glabellar furrows, thus changing their directions with respect to the midline. 3. Shallowing and increasing irregularity of the course of the depressions connecting inner parts of glabellar furrows. 4. Slight expansion of glabella across basal lobes so that its greatest width is measured here. 5. Flattening of occipital ring and conformation of its longitudinal profile with the curve of the rest of the glabella. 6. Increase in forward slope of cranidium.

Some of the intermediate stages show a short and faint furrow along the midline on the frontal lobe, noticed principally as an elongate spot bare of typical surface granulation. This does not enter the preglabellar furrow.

Free cheek. The smallest free cheek (pl. 86, fig. 10), with a border length of 1.5 mm., is quite similar to the largest. The eye is not quite so far back; the anterior straight portion and posterior sharply rounded portion of outer margin not so distinctly differentiated; maximum length along border a little over three times the width through the eye (vs. 2.5 times in largest specimen), reflecting the lesser convexity of the curve of the facial suture around the eye; visual surface considerably less bulbous than in largest specimen; ornamentation less dense but coarser with a marginal row of spine-like granules.

Hypostoma. The smallest hypostoma has a midlength of 0.75 mm. and is distinctly similar to the largest specimen. The lateral and posterior borders are a little narrower and furrows defining the middle body more distinct; maculae not distinguishable; anterior margin of middle body set slightly more forward with respect to that of lateral borders; surface ornamentation much less developed, particularly on posterior lobe of middle body; short spines prominent on posterior margin.

Pygidium. The smaller specimens of the pygidium are better preserved than the largest but show few features that appear distinctly different. The smallest pygidium (pl. 87, fig. 1) has a maximum width of 1.4 mm. and length of 1.8 mm. from articulating furrow to tips of pleural projections. At this stage the furrow and elevation suggesting the third rudimentary axial segment are absent; the ventral margin is completely in one plane (i.e., without the dorsally arched posterior median portion); the pleural projections of the first segment are directed less strongly outward (only 10 degrees to the midline); and the ornamentation is coarser and sparser.

A specimen of intermediate size (pl. 87, fig. 3), the only one bearing first and second pleural projections intact, shows that the tip of the second extends slightly behind that of the first.

HELIOMEROIDES RAYMONDI (Bradley)
Plate 85, figures 6–14

Heliomera raymondi BRADLEY, 1930, Fauna of the Kimmswick limestone of Missouri and Illinois: Contrib. Walker Mus., vol. 2, no. 6, pp. 282–283, pl. 30, fig. 3.

Horizon and locality.—Kimmswick limestone, near Batchtown, Illinois; collected by the University of Chicago Calhoun County Expedition, 1906.

Specimens.—Holotype and only known specimen, Walker Museum 20692; plastotype USNM 67351.

Description.—This species is known from one very well preserved specimen of the glabella. The anterior border is preserved but only the innermost margins of the cheek lobes.

Glabella transversely subelliptical, width about 1.6 the midlength, width a maximum across the second glabellar lobes, but only very slightly less across the first. General convexity moderate transversely and longitudinally. The several lobes of the glabella and the occipital ring all possess independent convexity. This is very strong for the lateral glabellar lobes. The lateral portions of the occipital furrow and the lateral glabellar furrows are very deep and equally developed. The transverse median portion of the occipital furrow is wider, and the two longitudinal furrows defining the median glabellar lobe are somewhat wider and shallower. Occipital ring convex, anterior surface sloping steeply into the occipital furrow, posterior margin gently convex backward; extremities of ring tapering to points; width about 4.5 the midlength; midlength 0.25 that of glabella. Median occipital node large and distinct but low and flat-topped.

Lateral portions of occipital furrow and lateral glabellar furrows inclined, respectively, outward and backward 70, 90, out-

ward and forward at 60 and 30 degrees to the midline. The readings on the glabellar furrows are for the proximal parts, as each furrow is not straight, but gently convex forward. First and second lobes about equal in size, third lobe smaller. The furrows decrease in length progressively forward, and proximally open by smooth transition into the broad longitudinal depressions which set off the median lobe and separate it completely from all the lateral lobes.

The posterior portion of the median lobe has parallel sides, its width 0.25 the maximum glabellar width; the frontal lobe expands to a maximum width along the preglabellar furrow, its maximum width over 0.4 the glabellar width. In dorsal view the anterior margin of the frontal lobe is very slightly concave medially; in true anterior view the preglabellar furrow is seen to arch very gently across the median region. The anterolateral extremities of the frontal lobe are acute. The posterior portion of the median lobe and the frontal lobe are more strongly convex than that region between the proximal ends of the third glabellar lobes. This causes a characteristic lateral profile (pl. 85, figs 7–8). The frontal lobe is, in fact, gently doubly convex, bearing along the midline a shallow but distinct furrow which widens and gradually disappears anteriorly.

The axial and preglabellar furrows are wide, rounded and smoothly confluent. The axial furrows are overhung by the convex extremities of the lateral lobes more than the preglabellar furrow by the frontal lobe. The anterior border is rather strongly convex, narrowest medially, where the anterior margin is gently concave backward along the rostral suture. It is smoothly continuous with the band adjoining the axial furrow inside the facial suture. There is a very obtuse angle in the anterior branch of the facial suture diagonally outward and forward from the third glabellar lobe.

The surface, except for the smooth furrows, is finely tuberculate.

HELIOMEROIDES TRETA Evitt, n. sp.
Plate 85, figures 15–23

Horizon and locality.—A granular limestone at the base of the Athens near Bland, Bland Co., Virginia.

Specimen.—Holotype and only known specimen USNM 116293.

Description.—Only one specimen of this species is known. It is an incomplete glabella in which the left posterior portion and the right anterior portion have been destroyed and the extremities of the left glabellar lobes damaged. No portions of the border or cheek lobes are preserved.

Glabella transversely subelliptical, width about 1.8 the midlength, width a maximum and equal across the first and second glabellar lobes. General convexity moderate transversely and longitudinally. The several lobes of the glabella and the occipital ring possess marked independent convexity. This is greatest for the median glabellar lobe, which is strongly arched, especially in the region between the inner ends of the second and third glabellar furrows.

Occipital furrow deep, even medially. Median portion gently convex posteriorly, lateral portions deepest, nearly straight, inclined outward and backward at 75 degrees to the midline. Occipital ring convex, posterior margin transverse medially, swinging forward to the sides so that laterally the ring tapers to a point; width of ring 5.5 times the midlength; midlength 0.23 that of the glabella. There is no distinct occipital node, although the ring bears a gentle median swelling.

Lateral glabellar furrows inclined outward and forward at, respectively, 85, 65 and 25 degrees to the midline. Second glabellar lobe the largest, first slightly smaller, third much smaller. The furrows are deep and rounded and decrease in length progressively forward. The first two are straight, the third slightly arcuate. The inner ends of the first and third are nearly in a longitudinal line. The inner ends of the lateral furrows are joined on each side by a broad and conspicuous depression, widest where the first and second furrows meet it (the inner anterior portion of the second lobe is thereby noticeably constricted at its base) but distinctly separating the second and third lobes from the median lobe. Across the base of the first lobe this depression is somewhat less pronounced. The floor of this depression or longitudinal furrow is smooth, impressed on the slope of the median lobe.

The median lobe is widest along the pre-

glabellar furrow, becomes constricted a short distance posteriorly by the incursion of the third glabellar furrows; behind this its width increases, nearly reaching the maximum. Width across frontal lobe one-third the maximum glabellar width, length 1.3 its own maximum width. The lobe, thus, has subparallel sides with a slight flare at the front. The margin of the frontal lobe is gently convex forward in dorsal view. In true anterior view the deep and rounded preglabellar furrow swings upward toward the midline. The frontal lobe thus terminates in acute points anterolaterally with a gentle concavity between (pl. 85, fig. 20). The median lobe is strongly arched longitudinally and transversely, standing considerably above the lateral lobes in anterior profile and with a nearly smooth but pronounced curve in lateral profile.

On the frontal lobe, extending along the midline from a point between the inner ends of the deepest parts of the third furrow to a point half way to the preglabellar furrow, is a row of four small but distinct pits (pl. 85, fig. 23), the first in front of an adventitious chip out of the surface. There is no furrow-like depression in this area.

The surface, except for the furrows which are smooth, is ornamented with small and rather closely spaced tubercles of varying size.

HELIOMEROIDES sp.

Heliomera sol (Billings), RAYMOND, P. E., 1905, Fauna of the Chazy limestone: Amer. Jour. Sci., ser. 4, vol. 20, pp. 381–382.

Heliomera sol (Billings), RAYMOND, P. E., 1910, Trilobites of the Chazy formation in Vermont: Rept. Vermont State Geol., 1909–1910, p. 245, pl. 38, fig. 12.

Heliomera sol (Billings), RAYMOND, P. E., 1910, Notes on Ordovician trilobites IV, new and old species from the Chazy: Ann. Carnegie Mus., vol. 7, pp. 77–78, pl. 17, fig. 12, text-fig. 9.

non *Cheirurus sol* BILLINGS, 1865, Paleozoic Fossils, 1: Geol. Surv. Canada, p. 288, fig. 276.

Horizon and Locality.—Raphistoma layers in the upper part of the lower Chazy, at Chazy, New York.

Specimen.—Apparently only one specimen of this species, an incomplete glabella is known. This is reportedly in the museum of Yale University, but cannot be found.

Discussion.—Raymond thrice described this specimen in the same words. Unfortunately the photograph which is reproduced in only two instances is poor, leaving details of many features in doubt, and it is obvious that the outline drawing reproduced as a text figure in his 1911 paper portrays the specimen only generally. We must rely, then, largely on his written description which I quote only in part:

> Glabella almost semicircular, with three pairs of long narrow glabellar furrows, all of which turn backward on their inner ends, each joining the one back of it, and the third pair joining the neck furrow, thus producing a central lobe like that of *Amphilichas*. This central lobe is of uniform width up to the inner ends of the first pair of glabellar furrows, but turns outward in front of that point. Toward the front of the median lobe there is a slight depression, somewhat similar to that sometimes seen in *Pliomera*. The first pair of glabellar furrows run backward at an angle of about 45 degrees, the second pair at a smaller angle, while the third pair are nearly parallel to the neck furrow. The glabellar lobes are narrow and club-shaped.

(1910a, p. 245) Raymond numbered the glabellar lobes and furrows from front to back.

His wording thus indicates the isolation of the median lobe, the presence of a median furrow on the frontal lobe and incidentally the narrow, club-shape of the lateral lobes. Knowing that these features exist, they can be recognized on the photograph and are shown on his outline drawing. Thus, the specimen possesses characteristics which definitely and completely differentiate it from the specimen which Billings described as *Cheirurus sol* and, at the same time, ally it with the other species of the new genus *Heliomeroides* described above.

Comparison between species of *Heliomeroides*

As a summary comparison between the four known species of *Heliomeroides* the most distinctive features are enumerated below:

H. teres Evitt, n. sp.

1. Lack of independent convexity of glabellar lobes
2. Smooth and gentle curve of lateral and anterior profiles
3. Elongate median spot devoid of ornament on frontal lobe
4. Ornamentation of very attenuate, spine-like tubercles

H. raymondi (Bradley)

1. Strong independent convexity of lateral glabellar lobes
2. Pronounced development of longitudinal furrow isolating median lobe
3. Flattened portion of median lobe, causing characteristic lateral profile
4. Median furrow on frontal lobe

H. treta Evitt, n.sp.

1. Strong convexity of median lobe
2. Slight and abrupt lateral expansion of frontal lobe
3. Great width of glabella compared to length
4. Four pits in median row on frontal lobe
5. Smooth but pronounced curve of median lobe in lateral profile

H. species (described by Raymond, 1905)

1. Isolated median lobe
2. Median furrow on frontal lobe

Genus HELIOMERA Raymond, 1905

Generic diagnosis.—Glabella semielliptical, considerably wider than long. Occipital ring longest (sag.) medially; occipital furrow complete, lateral portions inclined outward and backward. Three pairs of glabellar furrows: the first two diverging slightly toward the sides, the third inclined rather strongly outward and forward. The furrows of the glabella thus have a slightly radial orientation. Median glabellar lobe not set off by distinct longitudinal furrows joining the inner ends of the glabellar furrows.

Cheek lobes, hypostoma, rostrum, thorax, and pygidium unknown. It is to be suspected, however, that these would be suggestive of *Heliomeroides.*

In the genotype species the median lobe of the glabella is less than one-third of the glabellar width, has a slight independent convexity, and lacks a median longitudinal groove or row of pits, but these features are not necessarily of generic significance.

Genotype.—*Cheirurus sol* Billings, by monotypy.

Other known species.—None.

Known range and distribution.—Middle (probably lower Middle) Ordovician of Newfoundland.

HELIOMERA SOL (Billings)
Plate 85, figures 24–29

Cheirurus sol BILLINGS, 1865, Paleozoic Fossils, 1: Geol. Surv. Canada, p. 288, fig. 276.

non *Heliomera sol* (Billings), RAYMOND, P. E., 1905, The fauna of the Chazy limestone: Amer. Jour. Sci., 4th ser., vol. 20, p. 381.

non *Heliomera sol* (Billings), RAYMOND, P. E., 1910, Trilobites of the Chazy formation in Vermont: Rept. Vermont State Geol., 1909–1910, p. 245, pl. 38, fig. 12.

non *Heliomera sol* (Billings), RAYMOND, P. E., 1910, Notes on Ordovician trilobites IV, new and old species from the Chazy: Ann. Carneg. Mus., vol. 7, pp. 77–78, pl. 17, fig. 12, text-fig. 9.

Horizon, locality and specimens.—In the collections of the National Museum of Canada are two trilobite cranidia labeled *Heliomera sol* (Billings). They are from two different localities in western Newfoundland. One is from the "N" division of Logan, or the upper unit of the Table Head series, at Table Head. Schuchert and Dunbar (1934) state that the faunal content of this unit suggests correlation with the Normanskill of New York, earlier accepted as Chazyan but now considered by some (Cooper and Cooper, 1946) as younger. The second specimen is from the "P" division of Logan, which Schuchert and Dunbar indicate is part of the Humber Arm series of probably post-Blackriveran Middle Ordovician age. Dr. Alice E. Wilson reports (personal communication) that, unfortunately, there is nothing on the specimens or their labels to indicate which one is from which locality. This is a regrettable circumstance, since it turns out that the specimens are not examples of the same trilobite. One is much larger than the other and is obviously the one upon which Billings' description was based. The other is a minute (1.3 mm. long) cranidium of a species of *Triarthrus.* Although referred to indirectly by the listing of two localities, this second specimen received no particular attention and, fortunately, seems not to have been considered at all in Billings' description of *Cheirurus sol.* Since species of *Triarthrus* occur in the Newfoundland section throughout the Table Head series, and in the Humber Arm series as well (Schuchert and Dunbar, 1934), and since specific identification of so immature a specimen would be unsound, the presence of this fossil aids not at all in determining

the respective localities of origin of these specimens. Hereinafter reference to "Billings' specimen" implies the true *Heliomera* cranidium only. I select this, the larger of the two cranidia just referred to, as lectotype; plastotype—USNM 116292.

Billings' specimen is an incompletely preserved glabella. The posterior portion has been damaged: the basal glabellar lobe on the right side and the left side of the occipital ring are broken away; the right side of the specimen is partially exfoliated. Nevertheless, the salient features of the glabella are readily distinguishable.

Description.—Billings' original brief description is here quoted in full:

> Glabella small, sub-circular; length three-fourths of the width, moderately convex; front and sides rounded; neck furrow extending all across; posterior pair of glabellar furrows situated just behind the mid-length; second pair half-way between the posterior pair and the front; anterior pair cutting the front margin, and having about one-third of the whole width of the glabella between them at the margin, extending obliquely backwards and inwards at an angle of about 45 degrees with the median line. All of the furrows extend inwards a little more then one-third the whole width of the glabella. The space along the median line which is not crossed by the glabellar furrows is more convex than the remainder of the glabella. Surface finely tubercular. Length of glabella 2 lines; width $2\frac{2}{3}$ lines.
>
> Locality and Formation: N, Table Head, and P, four miles NE from Portland Creek, Newfoundland; Quebec group.
>
> Collector: J. Richardson.

(Billings, 1865, p. 288).

Several features, some of which Billings failed to mention, should be pointed out to further define the species and for comparison with the species of *Heliomeroides*.

No parts of the cheek lobes are exposed in Billings' specimen. On the right side the specimen is broken across the lateral glabellar lobes. On the left side the matrix still conceals the extremities of the lobes. This makes it appear that the three lobes are of approximately the same width (tr.) but it is much more likely that their width increases posteriorly, so that the outline of the complete glabella would be semicircular, rather than subcircular as Billings states and as it appears at first glance.

The occipital ring is longest behind the median glabellar lobe. In this region the occipital furrow is narrow and transverse. Behind the basal lobe the furrow is wider and deeper and inclines backward so that the occipital ring shortens (ex-sag.) laterally. For a short distance behind the base of the basal lobe the occipital furrow is bipartite, isolating a small, very slightly elevated elongate area. Probably the test is exfoliated in this region and this is a structure which occurs on the inner surface. It is doubtful if it would appear on the exterior. The occipital ring is gently convex and along the midline bears a rather large but low and rounded median node in its posterior part. The posterior margin is convex backward.

The lateral glabellar lobes possess a moderate degree of independent convexity, this being greatest for the posterior slope of the basal lobes. The lateral glabellar furrows are of rather constant depth, wide and semicircular in cross section. Three which are well exposed terminate by shallowing abruptly at their inner ends. The lateral portions of the occipital furrow and the three lateral glabellar furrows are inclined outward and backward at 80 and 85 degrees, outward and forward at 80 and 55 degrees to the midline, respectively. An angle of 45 degrees for the third furrows, as Billings gives, is low. The three lateral lobes are smoothly and distinctly connected with the median lobe (pl. 85, fig. 24) and, while the latter possesses a slight independent convexity (pl. 85, fig. 25), it is not set off by distinct furrows and thus the inner ends of the lateral glabellar furrows are not joined one to the other.

The frontal lobe is subtrapezoidal with an anterior margin which is transverse and, at least medially, straight. The frontal lobe bears a broad (tr.) and short (sag.) depression in the median region extending upward from the marginal furrow, but there is distinctly no longitudinal median groove or row of pits on the frontal lobe. Small portions of the anterior marginal furrow and border are exposed near the midline. The furrow is rounded in cross section and the border gently convex and approximately horizontal, but the anterior margin is not exposed.

In lateral profile (pl. 85, fig. 26) the curve of the median glabellar lobe is gently convex, without extreme changes in curvature, though becoming more convex on the frontal

lobe. In transverse profile (pl. 85, fig. 25) the glabella is gently convex with the median lobe slightly elevated.

The original illustration which Billings presented is a very diagrammatic line drawing. Comparison with the photographs in this paper will indicate its inaccuracies. The most important and confusing of these specimen indicate that such furrows do not exist in *Heliomera sol*, and there is no suggestion of their existence in his description. Nor is there mention of the longitudinal furrow on the median lobe and, indeed, this is not suggested on the diagram, although Raymond lists it as one of the generic features of *Heliomera*.

TABLE 1.—SIGNIFICANT DATA ON THE GLABELLAS OF THE FIVE SPECIES OF *Heliomera* AND *Heliomeroides* HERE CONSIDERED.

		Heliomera sol	*Heliomeroides teres*	*Heliomeroides raymondi*	*Heliomeroides trela*	*Heliomeroides* sp. (Raymond's)
Glabellar width / Length		1.5[1]	1.6	1.6	1.8	1.6[2]
Max. length of occipital ring / Glabellar midlength		.36	.25 (.17)[3]	.25	.23	.23[2]
Width of occipital ring / Its midlength		4.5	6.0 (5.5[4])	4.5	5.5	5.5[2]
Min. width of median lobe / Width of frontal lobe		.6	.62	.58	.9	.7[2]
Min. width of median lobe / Glabellar width		.25[1]	.24	.25	.27	.27[2]
Inclination of lateral portions of occipital and 1st, 2nd and 3rd lateral glabellar furrows (degrees)	O	80b	80b	70b	75b	85b[2]
	1	85b[1]	85f	90	85f	80f[2]
	2	80f	65f	60f	65f	60f[2]
	3	55f	25f	30f	25f	45f[2]
Order of increasing independent convexity of lateral lobes		2	1	3	4	?
Order of increasing convexity of median lobe		2	1	4	3	?
Structure on frontal lobe		none	"bald spot"	furrow	four pits	furrow

[1] Estimated.
[2] Approximations based on Raymond's photograph.
[3] Midlength of occipital ring / Glabellar midlength.
[4] Width of occipital ring / Its maximum length.

is the pair of hachure lines with which Billings attempted to delineate the median glabellar lobe. These seem to have been interpreted by Raymond and Bradley to correspond to the furrows which they found in species, here referred to *Heliomeroides*, joining the inner ends of the lateral glabellar furrows. The casts made from Billings'

Family HARPIDAE Hawle & Corda, 1847
Genus DOLICHOHARPES
Whittington, 1949

Discussion.—Whittington (1948) reviews the rather simple history of the names of the two genera to which all species of harpid trilobites until recently had been referred:

Harpes Goldfuss, 1839, and *Eoharpes* Raymond, 1905 (proposed by Raymond to replace *Harpina* Novak, 1885, preoccupied). Novak had distinguished these two genera on the basis of the hypostoma but this part of the test is so rarely encountered that only those described by Novak (1885) and Barrande (1852) and amounting to a total of four species out of some 30 or 40 in the family had been known; thus, proving an unsuitable criterion for generic distinction. In place of this, geologic age has been used as the basis for separation: all Ordovician harpids being assigned to *Eoharpes*, all younger ones to *Harpes*. A recent study of British harpids has led Whittington (1950) to the conclusion that the species placed in each of these genera are in reality heterogeneric and that more reliable criteria can be used in the establishment of recognizable genera.

The genus *Dolichoharpes* was proposed by Whittington (1949) with *D. uniserialis* (Raymond) from the Kimmswick limestone of Missouri as genotype. At the same time he described a second species, *D. reticulata* Whittington, from the Edinburg limestone of Virginia. Raymond had based the first species on the cephalon alone. The second species was represented in Whittington's material by only a single large but incomplete cephalon (the holotype) and a few smaller fragments. Bradley (1930) had described other specimens of *D. uniserialis* from the Kimmswick but, as neither the specimens nor this paper were available to Whittington, he discussed only the cephalon in making the generic diagnosis.

In the lower Lincolnshire limestone *D. reticulata* is represented by a small number of fragmentary cephala, several hypostomas, a few thoracic segments, and two pygidia. Thus it is possible to formulate a complete generic diagnosis. Despite their relative scarcity, the specimens of the cephalon represent individuals of considerably different size. This permits considerable information to be gleaned concerning the ontogenetic development of the harpid cephalon. The hypostomas yield additional data and are of particular interest because of their rarity.

The generic diagnosis has been recently published (Whittington, 1949, pp. 277–278) and need not be repeated here.

Hypostoma pear-shaped, longer than wide, anterior margin gently convex forward, lateral margins convergent posteriorly with a slight deflection below posterior wings, straight behind this. Posterior margin nearly straight and transverse. Anterior border narrow and flexed strongly ventrad; lateral border widest within anterior wings, very narrow posteriorly; posterior border lacking, the middle body continuous with posterior doublure. Anterior wing formed by simple dorsal continuation of anterior part of lateral border: posterior wing behind the midpoint. Middle body convex, strongly so anteriorly; widest across anterior lobe and extending all the way to the posterior margin without intervention of posterior marginal furrow. Middle furrows distinct, beginning far forward, oblique, separating elongate anterolateral extensions of the posterior lobe of the middle body; a branch of the lateral marginal furrow turns slightly onto the middle body at the posterolateral extremity, thus separating a very short posterolateral extension of the posterior lobe.

Number of thoracic segments unknown. Each segment of typical harpid design with strongly convex axial ring; ring and adjoining articulating furrow subequal in length. Inner part of pleura horizontal, parallel-sided, with strong anterior and posterior bands separated by deep pleural furrow which swings backward at its extremity; outer part of pleura short, sharply bent downward; large anterolateral facet.

Pygidial width (tr.) several times its length (sag.), surfaces rounded off steeply to the rear; axis prominent with strongly convex anterior portion but merging with the lateral surfaces posteriorly; bearing three or four distinct axial rings forward, and two or three additional rudimentary ones. Pleural lobes with three or four distinct pleurae separated by rib furrows and bearing pleural furrows; pleurae and furrows diminishing in distinctness posteriorly and all curving backward toward the margin. Pleural lobes with distinct anterolateral facet.

In interior view the cephalon, thorax and pygidium have appendifers developed as very low, elongate prominences at extremities of articulating and occipital furrows. Articulation by means of narrow flanges on straight segmental margins and minute, simple ball-and-socket joints in line with

axial furrows, the balls on the anterior margins.

Genotype.—*Eoharpes uniserialis* Raymond.

Other known species.—*D. reticulata* Whittington, *D. doranni* (Portlock).

Known range and distribution.—Middle and Upper Ordovician of central and eastern North America and Ireland.

DOLICHOHARPES RETICULATA Whittington

Plate 87, figures 5–10; plate 88, figures 1–8

D. reticulata, WHITTINGTON, H. B., 1949, *Dolichoharpes* and the origin of the harpid fringe: Am. Jour. Sci., vol. 247, pp. 280–283, pl. 1, figs. 2, 6, 7; pl. 2, figs. 1–6.

Horizon and locality.—Lower Lincolnshire limestone, 2 miles southwest of Strasburg, Shenandoah County, Virginia.

Specimens.—All specimens figured in this paper are in U. S. National Museum.

Description.—Cephalon. The completeness of the original description of the cephalon which is the holotype makes it necessary to mention here only a few points of interest or concerning features not preserved on the holotype.

Along with the other major cephalic features, the glabella (lacking in the holotype) of the present species is like that of *D. uniserialis* (Raymond). Width of glabella in front of occipital ring about 1.2 the midlength of this portion. The reticulate pattern of ridges on the glabella is of a considerably finer mesh than on the rest of the cephalon, but otherwise similar. In the largest specimen (pl. 87, fig. 9) the axis of the glabella is inclined forward and downward at about 20 degrees below the horizontal. A low occipital node occupies the forward half of the occipital ring along the midline. The occipital doublure reaches forward medially not quite to the articulating furrow, its anterior edge an even curve. Each ocular ridge narrow, with (in the smaller specimens at least) a single row of closely spaced granules along its crest. Similar granules cover the upper surface of the group of eye tubercles (pl. 88, fig. 2). In interior view each ocular ridge shows as a distinct rounded channel trending straight from the eye inward and slightly forward to the axial furrow but not traceable across this. In ventral view the girder has smooth sides but its crest is ornamented with rows of minute granules. The lower and upper rims have similar ornamentation but somewhat coarser, and just below the median ridge along which the suture runs is a row of much more distantly spaced ornamental projections, each consisting of a very short and stout shaft surmounted by two or three very short divergent barbs. These are present only in front of the bases of the posterior prolongations around the front of the cephalon. The articulating surfaces along the posterior margin are like those described below for the thorax.

My specimens do not exactly agree with Whittington's description of the structure of the fringe. He states:

> In complete specimens of the fringe, or in separate, single lamellae, the base of the pits is represented by a thin layer of silica, much thinner than the walls of the pits or the areas between the pits. Only rarely is seen a tiny hole connecting opposing pits, and where this occurs it is apparently due to breakage or abrasion of the specimen. Since the material is so perfectly silicified, and very fine details of the ornament are preserved, it seems reasonable to infer that in the living animal the bases of the pits were covered by a thin layer of chitin.

(Whittington, 1949, p. 282.) In the present specimens of separate lamellae almost all of the bases of the pits are sealed over in the manner described, and the few perforations which are present could as easily be the result of breakage or abrasion as original structures. However, in the specimen illustrated in pl. 88, figs. 1a–d, in which the upper and lower lamellae are still in position, a considerable number (about 15%) of the pairs of opposing pits are connected by distinct and perfectly round holes. These are distributed without regard to position over the internal and external portions of the fringe, on the prolongation as well as on the anterior part of the cephalon. It is difficult to interpret them as anything but original structures, since they are not in positions subject to mechanical wear until the lamellae are separated. That at least some of the opposing pits are connected by openings seems to reduce to insignificance the single difference in fringe structure between the Ordovician *Dolichoharpes* and the Devo-

nian specimens discussed by Richter (1921, pp. 184–187, pl. 16, figs. 4, 5).

Hypostoma. Pear-shaped, the maximum width across anterior wings about equal to the midlength; width across line of posterior wings about 0.75 the midlength.

Anterior lobe of middle body strongly and evenly convex, broadly rounded in front; posterior lobe much more gently convex. Middle body extending nearly the entire length of the hypostoma, separated from the anterior margin by the narrow anterior border which is flexed very strongly ventrad along the midline; surface of posterior lobe vertical along posterior margin, no posterior marginal furrow present. Maximum width of middle body across anterior lobe 0.65 the hypostomal midlength and only very slightly greater than width across posterior lobe. Anterior border flat, though flexed, attaining a maximum width anterolaterally and then narrowing along margin of anterior wing, continuing extremely narrow along lateral margin of wing. Anterior margin gently convex forward, more strongly rounded in front of the wing and continuous with the straight margin of wing which is parallel to the midline. Lateral border wide and gently convex within the anterior wing, narrowing behind this and continued to the posterolateral corners of the hypostoma as a narrow marginal ridge. This is slightly offset below the posterior wing, forming a small shoulder. In front of this the lateral margin is gently concave outward, behind it straight and directed inward and backward at 30 degrees to the midline. The border is continued dorsad onto the doublure which is very narrow between the two wings, wider where it is drawn out dorsally into the posterior wing, narrow again across the posterior, its inner edge in a smooth curve and its posterior portion continuous with the surface of the middle body.

The anterior wing is formed by the dorsal extension of the lateral border, its dorsal edge formed by the narrow continuation of the anterior border. This is without strong articulating points, but in side view there is a slight indentation along the dorsal edge.

The furrows which surround the middle body conform as follows: The ventral flexure of the anterior border forms a narrow anterior marginal furrow between it and the anterior slope of the middle body. Anterolaterally, a much more gentle depression separates middle body from anterior extremity of lateral border; this deepens posteriorly into a prominent subtriangular cavity in line with posterior corners of anterior wings. From each such depression a rather broad and very shallow middle furrow curves onto the middle body at an angle of about 20 degrees to the midline, terminating at a point about 0.75 the midlength of the middle body from its anterior extremity; distance between posterior terminations of middle furrows about 0.4 the width of hypostoma in line with posterior wings. Each furrow is deepest at its anterior inception but always broad and quite shallow. In the largest specimen small ovate maculae lie on the middle body in line with the middle furrows just beyond their ends, but in the

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EXPLANATION OF PLATE 87

Heliomeroides teres Evitt, n. sp. (p. 594)

FIGS. *1a–e*—pygidium, USNM 116312, ×8. *a*, dorsal stereogram; *b*, ventral view; *c*, left lateral view; *d–e*, posterior and anterior views.

2a–b—pygidium, USNM 116313, ×7, dorsal and right lateral views.

3—pygidium, USNM 116314, ×8, dorsal view.

4a–d—pygidium, USNM 116315, ×5. *a–b*, dorsal and ventral stereograms; *c–d*, right lateral and anterior views.

Dolichoharpes reticulata Whittington (p. 607)

FIGS. *5a–b*—cephalon, USNM 116316, ×4.1, dorsal stereogram and right lateral view.

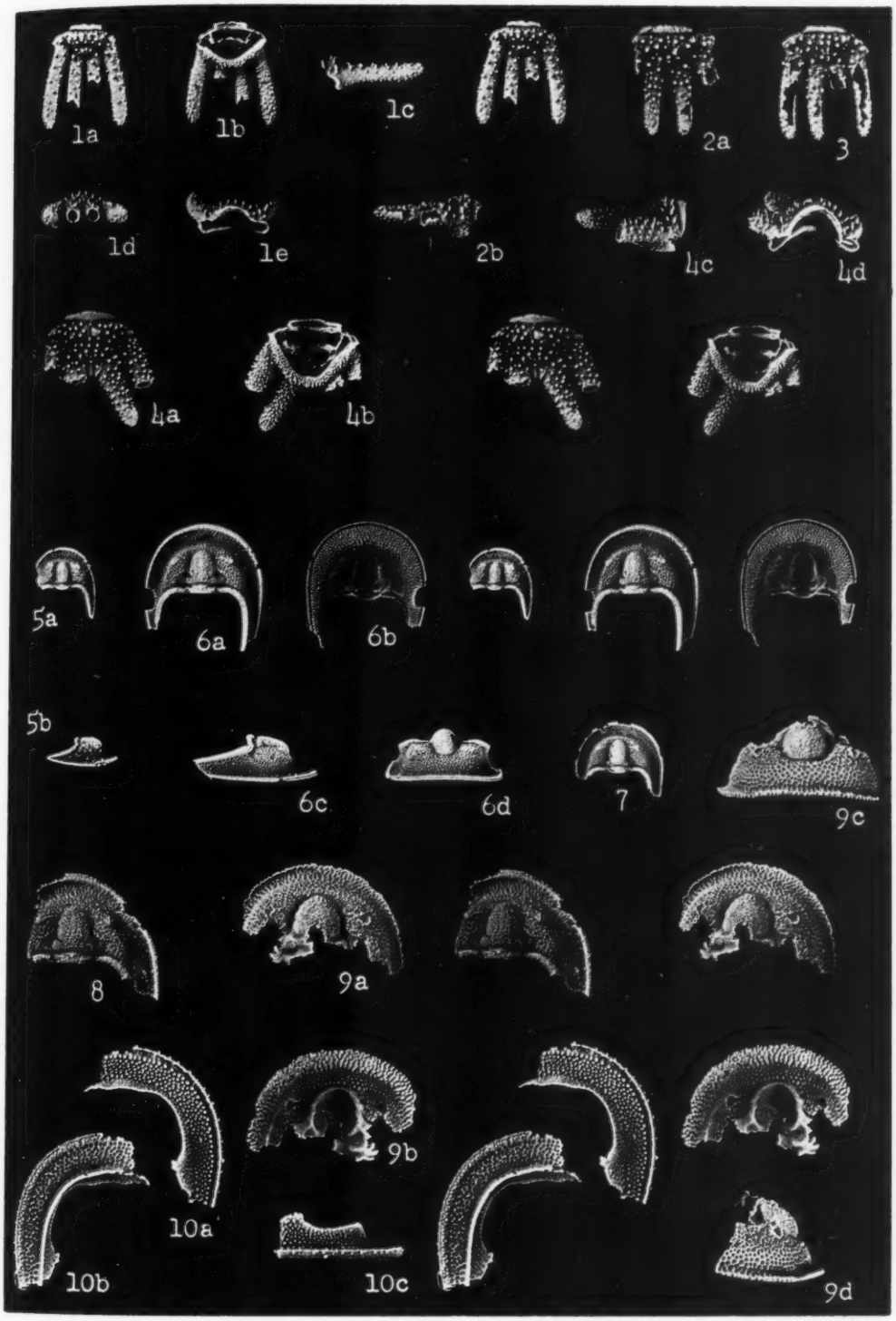
6a–d—cephalon, USNM 116318, ×3.2. *a–b*, dorsal and ventral stereograms; *c–d*, right lateral and anterior views.

7—cephalon, USNM 116317, ×3.2, dorsal view.

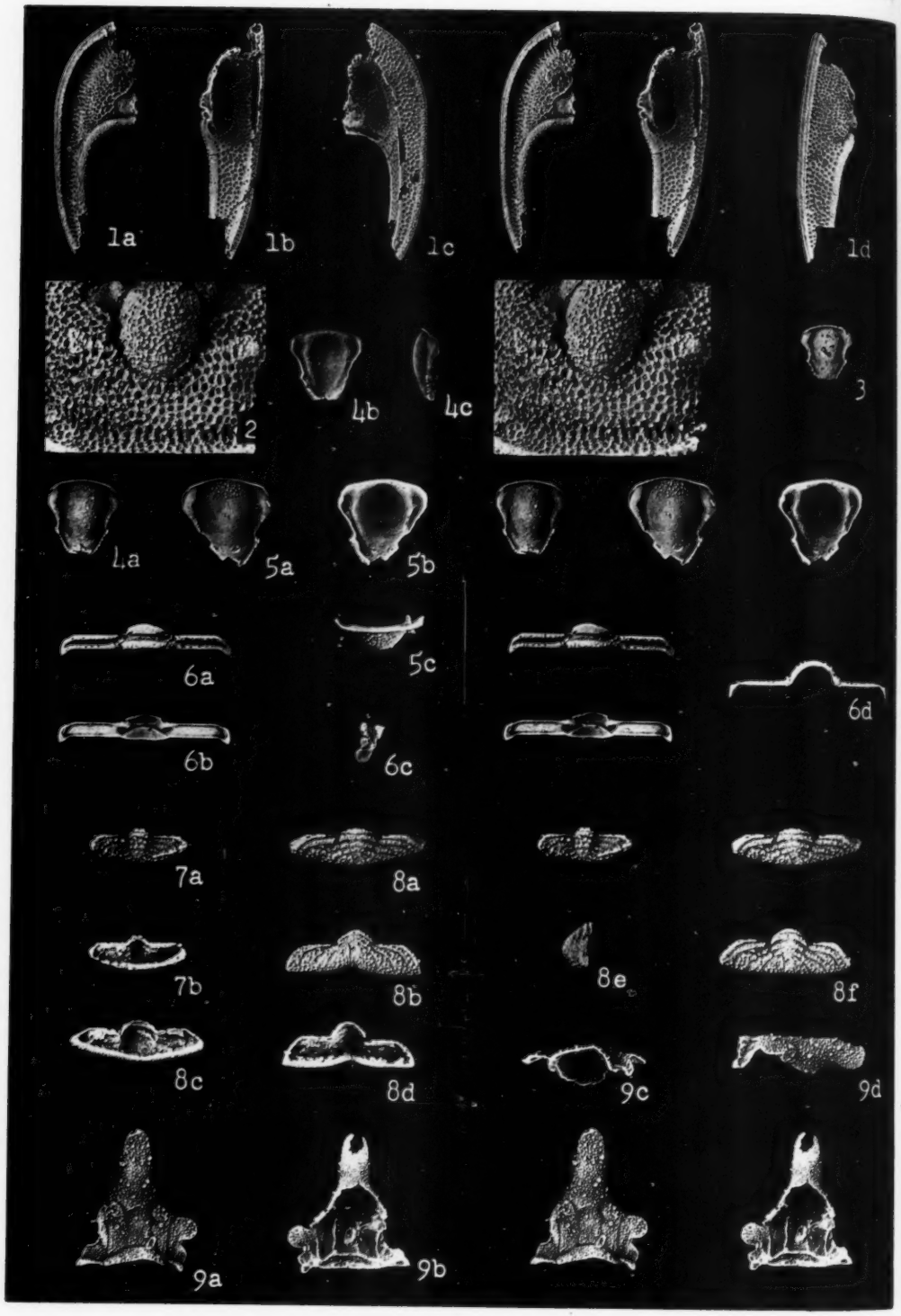
8—cephalon, USNM 116319, ×3.2, dorsal view.

9a–d—cephalon, USNM 116320, ×2.3. *a–b*, dorsal and ventral stereograms; *c–d*, anterior and right lateral views.

10a–c—lower lamella of fringe, USNM 116321, ×6. *a–b*, dorsal and ventral stereograms; *c*, right lateral view.



Evitt, Middle Ordovician trilobites



Evitt, Middle Ordovician trilobites

smaller specimens these are not apparent. In the largest specimen the middle body is crossed by an adventitious line of fine wrinkles. Between the posterior wing and the posterolateral corner of the hypostoma, the lateral border is separated from the posterior lobe of the middle body by a narrow and impressed marginal furrow. This is shallowest immediately anterior to the posterior wing and is faint where it joins the deeper middle furrow so that the oblique and narrow lateral portion of the posterior lobe is in line and nearly continuous with the lateral border just anterior to the posterior wing. At the posterolateral extremity the lateral marginal furrow bifurcates, both branches very short, one narrow and deeply impressed, continuing to separate off a lateral border as the whole hypostomal surface curves dorsad, the other broad and shallow, extending a very short distance onto the middle body and disappearing. The small portion of the middle body between these is inflated into a small lobe.

The anterior slope of the middle body is ornamented with a scattering of granules; the rest of the middle body smooth. The lateral border bears a single row of granules increasing in size from the posterior corner of the anterior wing to the posterior wing, then constant in size to the posterolateral corner except that at the shoulder just below the posterior wing a single small projection is differently developed into a structure exactly similar to the ornamentation on the marginal band of the lower lamella on the cephalon described above.

In interior view the ovate maculae are visible as well as the prominences representing the deepest portions of the lateral marginal furrows at the inception of the middle furrows.

Little is known about the articulation of the harpid hypostoma. It seems that the attachments to the upper part of the cephalon must have been by means of membranes and muscles only and probably the margin of the ventrally flexed anterior border was in contact with the inner edge of the lower lamella in front of the glabella.

Thorax. Number of thoracic segments unknown. Axial ring highly arched; axial furrows not distinct. Ring strongly convex longitudinally, posterior margin straight, midlength a little over half the midlength between posterior margin and posterior edge of half-ring, ring lengthening (sag.) at extremities to include entire segmental length. Ring doublure extends forward medially to below articulating furrow, its forward edge a smoothly convex curve. Articulating furrow transverse, broad and shallow medially, except for a very narrow and deeply impressed portion just behind articulating half-ring; narrowing, deepening and swinging forward to the anterior margin. Half-ring less strongly convex longitudinally than axial ring, longer than this medially; anterior margin evenly convex forward, in side view crest of half-ring very slightly below that of axial ring behind.

Inner part of pleura with straight and parallel anterior and posterior margins, marked by a deep and wide pleural furrow along its midline separating pleura into anterior and posterior bands; bands and

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EXPLANATION OF PLATE 88

Dolichoharpes reticulata Whittington (p. 607)

FIGS. *1a–d*—cephalon with lower lamella of fringe in place, USNM 116322, ×3.2. *a–b*, dorsal and oblique interior stereograms; *c*, ventral view; *d*, left lateral view.

2—cephalon, USNM 116319, ×8, oblique anterior stereogram showing eyes and glabella.

3—hypostoma, ×8 (specimen destroyed), ventral view.

4a–c—hypostoma, USNM 116323, ×7. *a*, ventral stereogram; *b–c*, dorsal and left lateral views.

5a–c—hypostoma, USNM 116324, ×4.1. *a–b*, ventral and dorsal stereograms; *c*, anterior view.

6a–d—thoracic segment, USNM 116325, ×5. *a–b*, dorsal and ventral stereograms; *c–d*, right lateral and posterior views.

7a–b—transitory pygidium, USNM 116326, ×12, dorsal stereogram and ventral view.

8a–f—pygidium, USNM 116327, ×5. *a*, true dorsal stereogram; *b*, true posterior view; *c*, ventral full surface view; *d*, true anterior view; *e*, right lateral view; *f*, exterior full surface view.

Amphilichas (*Probolichas*) *pandus* Evitt, n. sp. (p. 614)

FIGS. *9a–d*—the holotype cranidium, USNM 116328, ×3.2. *a–b*, dorsal and ventral stereograms; *c*, posterior view; *d*, right lateral view.

furrow subequal in width (ex-sag), anterior band a little higher and more strongly convex than posterior one. At fulcrum the pleural furrow narrows and disappears rapidly after bending slightly backward, coming to an acute point. Around this extremity the bands are continuous after bending backward, but the anterior band is much narrower and the posterior band wider than in the rest of their courses. Outer part of pleura bent strongly downward, very short and occupied mostly by a prominent anterolateral facet with straight anterior and rounded distal margins.

Axial ring and anterior pleural band ornamented with a single row of large granules, the crest of axial ring bearing a cluster of smaller ones. At the fulcrum, where the two bands meet around the extremity of the pleural furrow, is a row of six to eight small granules, a central one of the group much larger than the rest.

In interior view, surface of inner part of pleura occupied by the broad gently convex ridge representing the pleural furrow, the two bands being very narrow linear areas adjacent to this. The rounded surfaces of the deepest parts of the articulating furrows are the only appendifers. The inner edge of the pleural doublure extends straight downward and backward from the midpoint of the anterior edge of the facet, until in line below the extremity of the pleural furrow, then bends at about 90 degrees, continuing to the posterior margin at the point of geniculation after another slight change in direction. In front of the sharp angle the inner edge of the doublure is greatly thickened and flexed inward, the end of this thickening (at the angle) forming the stop for the enrolling movement by blocking the passage of the leading edge of the facet of the next posterior segment.

The articulating surfaces consist of a very narrow, double-edged groove along each straight margin of the pleura and a ball-and-socket joint proximally in line with this, the ball minute, at each anterolateral extremity of the axial ring, the socket on the posterior surface of the posterolateral extremity of the ring.

There seems to be little modification in the formation of the outer part of the pleura in different segments through the thorax. In what are probably more posterior segments the outer part is directed a little more strongly backward.

Pygidium. Composed of four (or possibly five) anchylosed segments, only three of which bear distinct axial rings. Short (sag.) and wide (tr.), with the surface sloping steeply backward in life position (pl. 88, fig. 8e). Maximum width nearly 4.5 the midlength in true dorsal view, 3.3 the full surface midlength.

Axis strongly convex anteriorly, defined laterally by a sharp change in slope where it meets the pleural lobe, its crest sloping steeply from front to rear; maximum width across first axial ring 1.5 the axial midlength; posteriorly the axial surface becomes smoothly confluent with median posterior portion of pygidium. In side view the axis is steeply sloping and the posterior pygidial extremity is bluntly rounded. Three axial rings subequally developed, the anterior one transverse, the others gently convex forward, separated by ring furrows deepest at the sides and shallow medially. Behind the third ring furrow and the two rib furrows extending from it, the posterior medial position of the pygidium is formed by a gently convex subtriangular area representing the fourth (and maybe a fifth) segment, the apex at the midline and long base along ventral margin. Each pleural lobe in front of this is composed of three pleurae, each with a pleural furrow separating it into subequal convex anterior and posterior bands. The bands and furrows decrease in distinctness from front to rear. The first segment is truncated anterolaterally by a subtriangular facet, somewhat less distinct than in thoracic segments. Proximal portion of anterior margin straight, bending backward at about 45 degrees to the midline in full surface view along the facet. The first pleural furrow makes a small angle with anterior margin near the axis, but then curves backward. The pleural and rib furrows are separated from the margin by a narrow border unmarked by furrows. In true dorsal view the posterolateral margins of the pygidium are nearly straight and inclined inward and backward at about 80 degrees to the midline, the posterior junction of these very broadly rounded. The surface of the

pleural lobes turns down steeply toward this margin, becomes vertical and is rolled narrowly under, then is continued by a strongly dorsally flexed doublure.

The ventral margin consists of two nearly straight coplanar lateral portions and a dorsally arched posterior median portion, the crest of this arch being a rounded obtuse angle in end view. In ventral view no appendifers are visible.

The surface is ornamented with granules, small and closely spaced along the narrow border, coarser and in single line along the pleural bands; doublure smooth.

Development.—Cephalon. The smallest cephalon found is shown in pl. 87, fig. 5 and has a midlength of 1.5 mm.; total length to tip of prolongation 1.7 the midlength; width in line with posterior margin 1.67 the midlength; maximum width would be across prolongations very slightly behind this. Lower lamella not preserved.

Glabella nearly parallel-sided, rather narrowly rounded in front, axial and preglabellar furrows distinct but not deeply impressed, least marked posteriorly; maximum width, across occipital ring, 0.6 the glabellar midlength. Glabella strongly convex transversely, its crest curving downward to the preglabellar furrow in side view but nearly straight behind this.

Occipital ring strongly convex longitudinally, posterior margin nearly straight medially and somewhat behind the line of the posterior margins of the lateral lobes, bending forward at the sides. Occipital furrow trifid, with short, narrow and deeply impressed lateral portions, straight and directed inward and backward at about 70 degrees to the midline; median portion (about 0.6 the total furrow length) much shallower and wider, transverse. The occipital ring thus limited is longest medially with tapering ends inclined forward; midlength of ring about 0.3 its width and nearly 0.2 the glabellar midlength. Anterior half of ring along midline occupied by a distinct occipital node.

The maximum width of glabella excluding occipital ring is across basal lobes and is about 0.7 its midlength and very slightly less than the width of occipital ring. Basal lobe short and narrow occupying only the steep sideward slope of the posterolateral corner; surface not at all inflated, bounded anteriorly by the first glabellar furrow which is a relatively large triangular impression, its inner extremity connected by a very fine depression to the occipital ring. The width (ex-sag.) of the first furrow measured along the axial furrow is nearly as great as the length (ex-sag.) of the first lobe, thus the anterior edge of the furrow is very oblique. Second and third furrows not accurately identifiable. Surface of first lobe smooth, rest of glabella covered with a fine, dense granulation. Each ala an indefinite subtriangular area continuous with posterior marginal furrow, only slightly lower than surface of cheek lobe and not separated from this by a distinct alar furrow; along axial furrow ala extends forward about half the way to the front of the glabella.

Cheek lobe very strongly convex to the side of anterior portion of glabella, much less so posteriorly. The line of a transverse section through cheek lobe and middle part of glabella is nearly flat outward from axial furrow and then bends downward in a smooth curve, becoming almost vertical to the side. A similar line through anterior portion of glabella rises rather steeply from axial furrow, crosses the summit of the cheek lobe in a narrow curve and declines, again nearly vertical, to the side. At the top of the outer slope of this anterior portion is the eye, its center separated from the glabellar midline by 1.3 the glabellar width in line with the eyes. A faint ocular ridge extends inward and slightly forward from the eye. The preglabellar field falls off steeply but not so steeply as the sides of the cheek lobes.

The preservation of the specimen does not permit a detailed statement with regard to the ornamentation on the cheek lobes. It seems to be reticulate but the ridges are wider than the diameter of the depressions between so that the surface does not have the appearance of an open network as in the larger specimens.

Posterior border strongly convex, extending at first straight outward from occipital ring, then increasing in elevation, curving backward and continuous with internal rim. Posterior marginal furrow smooth, separating the cheek lobe from the elevated posterior border, extending straight outward, impressed below cheek surface distal to ala,

disappearing just beyond the bend of the posterior border.

The fringe descends steeply from upper surface, then flattens onto external portion, girder not apparent in dorsal view of upper lamella. External portion of fringe widest anteriorly where (including the rim) it accounts for more than 0.25 the cephalic midlength, narrowing gradually and continuously to tip of prolongation; turned slightly upward across front of cephalon but only here is the upper lamella concave upward; to the sides the outward slope is lessened but not horizontal or upturned. External rim strongly convex, slightly wider anteriorly than along prolongation. Internal rim on prolongation considerably wider than external one. In dorsal view internal rim straight and inclined outward and backward at 10 degrees to the midline; in side view, internal and external rims meet in a point at tip of prolongation and include an angle of about 30 degrees.

The pits on the fringe are closely spaced but irregularly distributed so that no radiating lines of pits and separating ridges are apparent on external portion. The surfaces between the pits appear to be smooth; there is no evidence of perforation of pit bases. The rim bears small granules in a row along its upper surface.

Developmental trends with increasing size. 1. Great lateral expansion of posterior portion of glabella; shift of maximum glabellar width from occipital ring to across basal lobes. 2. Modification of occipital furrow so that the lateral portions are in nearly a transverse line and less clearly differentiated from the medial part. 3. Increase in size and inflation of first glabellar lobes. 4. Appearance of second and third glabellar furrows defining second and third lobes. 5. Development of the spiral ridges which ornament the first and second lobes. 6. Posterior migration of the eye. 7. Disappearance of the strongly convex anterior portion of the cheek lobe. 8. Increase in size and depression of the alae. 9. Increase in length of prolongations and concomitant with this a decrease in angle between the internal and external rims at their tips. 10. Increase in width of external fringe on prolongations. 11. Acquisition of upwardly concave surface by entire external portion of upper lamella. 12. Increase in forward slope of axis of glabella. 13. Gradual inward bending of the prolongations. 14. Arrangement of the pits on the external fringe into radiating lines separated by ridges. 15. Perforation of some of the pit bases so that opposing pits become connected. 16. Development of more open reticulate ornamentation on cheek lobes and glabella; appearance of additional rows of granules on external rim.

For purposes of comparison I give below, in order of increasing cephalic midlength, selected proportions of features on the four best preserved cephala (including the smallest): midlength, 1.5, 2.4, 3.2, 4.1 mm.; total length to tip of prolongation (estimated where possible) divided by midlength, 1.73, 2.2, 2.3, ?; width in line with posterior margin divided by midlength, 1.67, 1.71, 1.70, 1.97; maximum glabellar width divided by glabellar midlength, .60, .70, .72, .79; maximum width of glabella excluding occipital ring divided by midlength of this portion, .70, .95, .98, 1.06; angle between rims at tip of prolongation (estimated where possible) 30, 20, 15, ? degrees; distance from anterior border to transverse line between eyes divided by midlength, .44, .49, .51, .52.

Hypostoma. The smallest hypostoma (pl. 88, fig. 3) has a midlength of 1.0 mm. and differs only very slightly from the larger specimen described above. The lateral extremities of the posterior lobe of the middle body are almost smoothly continuous with the lateral borders in front of the shoulders below the posterior wings. The midlength is a little less, relative to the maximum width.

Pygidium. The smallest pygidium found is a meraspid specimen shown in pl. 88 fig. 7 and has a midlength of 0.37 mm. Maximum width across posterior corners of anterolateral facets 3.4 the midlength. Posterior margin a very gentle and smooth curve between these points. Axis strongly convex, widest across first ring, not quite 0.25 the pygidial width, extending all the way to posterior margin but at posterior extremity its surface smoothly continuous with the pleurae to the sides. Position of axial furrows indicated by abrupt change in slope between axis and pleurae anteriorly, inclined inward and backward at about 15 degrees

to the midline. Six axial rings discernible, decreasing in distinctness posteriorly, the last two marked only by rows of granules on the axis. Each pleural lobe composed of a large, flat, subtriangular area and a vertical outer portion, truncated anterolaterally by the facet; anterior margin straight to inner extremity of facet, straight part about 0.3 the maximum pygidial width. Flat surface of pleural lobe crossed by three distinct rib furrows which curve outward and backward from first three ring furrows. On the first pleura a pleural furrow extends nearly parallel to the anterior margin from the axial furrow about half way across the lobe and then curves backward to the fulcrum. The second pleura is entire at the axial furrow, but a pleural furrow is visible extending a short distance proximally from the fulcrum and then disappearing. No pleural furrow is visible on the other segments. The fourth, fifth and sixth segments are indicated by rows of granules extending outward from the axial furrow but other structures are not visible here.

The vertical outer part of the pleural lobe is strongly developed on the anterior three segments; posteriorly this surface is continuous with the posterior median surface but the latter is turned down more gently and rolled under. The inner horizontal and outer vertical parts of the first three segments are separated by a row of prominent granules decreasing in size posteriorly along the line of the fulcrum. The pleural ribs and the axial rings of all segments bear rows of granules.

By the structure of the anterior segments, which strongly resemble the large free thoracic segments, and by the configuration of the posterior median portion, which suggests the general shape of the larger pygidium, the small specimen can be recognized as a young stage of the larger, but the parts of the true pygidium are so small, if indeed they are present at all, that nothing can be told of them.

Since the larger pygidium does not possess the conspicuous row of granules between the inner and outer parts of the pleurae, it appears that this young pygidium represents a stage so early that at least four of the true thoracic segments of the holaspis are still included here. Since none of the segments bears a marker which would identify it specifically it is impossible to say how early is this stage.

Family LICHIDAE Corda, 1847
Genus AMPHILICHAS Raymond, 1905
Subgenus PROBOLICHAS Phleger, 1936

Discussion.—Phleger (1936) presented an extensive revision of the family Lichidae, proposing a number of new genera, among them *Probolichas*. This genus was erected for lichids of the type of *Tetralichas* (=*Amphilichas* partim, according to Warburg) but with the frontal lobe prolonged into a proboscis. *Hoplolichas robbinsi* Ulrich (Ulrich, 1892; Clarke, 1897) from the Trentonian Galena limestone of Minnesota (not Upper Ordovician as stated by Phleger) was designated as genotype.

Warburg (1939) criticized the work of Phleger in very strong terms and questioned the validity of his treatment of the family. She rejected the genus *Probolichas*, considering it a partial synonym of *Amphilichas* on the grounds that the anterior prolongation of the glabella is not a feature of generic significance, while the glabellar lobation in *P. robbinsi* is like that of the majority of species referred to *Amphilichas*. A tendency toward anterior production of the glabella is evidenced in species belonging to several different genera of the family. Thus, a development of a proboscis very similar to that in *A. robbinsi* is demonstrated in the variety of *Lichas pachyrhinus* (Dalman) described as *L. pachyrhinus* var. *longerostrata* by Schmidt (1885); spatulate prominences are developed in *Platylichas*, while more pointed ones occur in *Hoplolichas*. On the other hand the characters of the glabellar lobes and furrows remain much more nearly constant.

I have chosen to resurrect the name *Probolichas* and to consider it as a subgenus of *Amphilichas*. The new species of this subgenus here described is very similar to the subgenotype and the relative proximity of the two in both time and space suggests that they are probably much more closely related than either is to more conservative species of *Amphilichas*.

Subgeneric diagnosis.—Lichids with the glabellar lobation of *Amphilichas* but with

the frontal lobe prolonged into a proboscis.

Subgenotype.—*Hoplolichas robbinsi* Ulrich.

Other known species.—*Amphilichas* (*Probolichas*) *pandus* Evitt, n. sp.

Known range and distribution of subgenus.—Middle Ordovician of central and eastern North America.

AMPHILICHAS (PROBOLICHAS) PANDUS
Evitt, n. sp.
Plate 88, figures 9a–d

Horizon and locality.—Lower part of the Lincolnshire limestone, 2 miles southwest of Strasburg, Shenandoah County, Virginia.

Specimen.—Holotype and only known specimen—USNM 116328.

Description.—This species is represented by a single slightly distorted cranidium. The left palpebral lobe is broken off and the posterior portion of the cranidium crushed slightly from the left side. The shape is dominated by the stout proboscis. Midlength of holotype 6.0 mm.; maximum width of complete cranidium across posterior border probably slightly greater than that across palpebral lobes and about 0.9 the midlength.

Glabellar sides subparallel posteriorly, each axial furrow swinging outward slightly toward anterior corner of palpebral lobe; axial furrow of equal impresssion throughout its length, beginning at facial suture at anterior corner of palpebral lobe. Occipital ring in dorsal view with posterior margin slightly convex forward. Ring distinctly defined laterally by the axial furrows which are convex outward across its extremities. Occipital furrow of three parts, the median portion between the prolonged anterior lateral furrows transverse and straight; each lateral portion behind the tricomposite lateral lobe slightly concave forward, trending outward and backward at an angle of about 60 degrees to the midline. Median portion of ring flat, sloping down rather steeply to the sides; longitudinal convexity slight. Width of ring about 0.6 the cranidial width across posterior margin; midlength 0.2 its width; length (tr.) of median portion of occipital furrow about one-third the ring width (tr.).

Posterior portion of median lobe and tricomposite lateral lobes subequal in width, each about 0.18 the width across palpebral lobes. Each prolonged anterior lateral furrow begins at the facial suture a short distance in front of the eye, curves upward, slightly inward and backward becoming parallel to the axis; anterior portion rather deeply impressed to a point a little in front of middle of palpebral lobe; posterior portion gently sinuous, less impressed, but distinctly continuous to occipital furrow.

Frontal lobe prolonged forward into prominent proboscis which is circular in cross section and with an average diameter nearly half the width of glabella in line with palpebral lobes; anterior extremity bluntly rounded. In side view the midline of the glabella is a straight horizontal line from just in front of the occipital furrow forward to a point slightly beyond the base of the proboscis, then is flexed slightly downward for a short distance, turning up just at the extremity. The line then curves evenly around the front of the proboscis, on the under side becoming subparallel to the anterior portion of the dorsal line, then curving downward again to the hypostomal suture. Thus, the proboscis appears to have, at the same time, a downward "kink" and an up-turned end.

Each palpebral lobe is flat and semicircular, its center opposite a point 0.3 the distance forward from the posterior margin to the anterior tip of the proboscis, its length about 0.17 this distance. In posterior view a line between the palpebral lobes is very slightly convex. Fixed cheek smoothly continuous with palpebral lobe; anterior portion a long triangle, its acute angle curving down to the occipital ring; separated from the posterior portion by a straight gentle depression extending from the junction of the axial and occipital furrows forward and outward onto the palpebral lobe just proximal to posterior corner of eye. Posterior portion of cheek in front of marginal furrow inclined steeply backward; posterior marginal furrow narrow and impressed; posterior border convex longitudinally, very narrow at axial furrow, widening laterally.

The lower margin of the cranidium between the eyes is broken, making it impossible to determine the course of the anterior branch of the facial suture. The posterior branch is complete on the left side: it at first

curves outward from the posterior corner of palpebral lobe along posterior base of eye, then cuts in a more direct but irregular line backward and slightly outward to the posterior margin.

In interior view the occipital doublure extends forward for about half the length of the occipital ring, its anterior margin subparallel to the occipital furrow. The furrows show as ridges but no appendifers are developed.

Dorsal surface ornamented with a dense covering of small tubercles, and a scattering of larger pointed ones which are most numerous on the proboscis. One particularly large one occurs in the middle of each tricomposite lateral lobe in line with the palpebral lobe, and two on the posterior margin of the occipital ring, one in line with each prolonged anterior lateral furrow.

Affinities.—The only described species known to the writer with which profitable comparison can be made is *A.* (*P.*) *robbinsi* (Ulrich) from the Galena limestone near Wycoff, Minnesota, as described and figured by Ulrich (1892) and Clarke (1897, pp. 747–748, figs. 68, 69). The general features of the cranidium are quite similar, but *A.* (*P.*) *robbinsi* differs from *A.* (*P.*) *pandus* in the following points: 1. the proboscis is straight, without flexure; 2. the anterior termination is more sharply rounded; 3. there is a sharp linear depression parallel to the facial suture immediately behind the eye; 4. the prolonged anterior lateral furrows maintain their depth to the occipital furrow.

DERIVATION OF NEW NAMES

Heliomeroides—*Heliomera*+εἰδής, resembling; referring to the similarity in general structure to the older genus *Heliomera*.

teres (*Heliomeroides*)—teres, rounded off; referring to the lack of strong independent convexity by the glabellar lobes and the smooth curves of the cranidium in profile view.

treta (*Heliomeroides*)—τρητός, perforate; referring to the median row of four pits on the frontal lobe of the glabella.

pandus (*Probolichas*)—pandus, bent or crooked; referring to the shape of the proboscis as seen in lateral view.

NOTE

On the plates only the left-hand element of each stereogram is numbered. In all the stereograms the left-hand element was taken with the plate vertically above the specimen. The right-hand element is slightly oblique. All specimens were coated with magnesium oxide before photographing. The silicified specimens were mounted on pins and photographed against a black background. No photographs are retouched.

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FRANCONIAN TRILOBITES OF THE CENTRAL APPALACHIANS

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ABSTRACT—A discussion on stratigraphy, fauna and age relations of Upper Cambrian beds in the central Appalachians is followed by lists of trilobite occurrences in 15 measured sections within the two belts of strata studied. The Ore Hill limestone member of the Gatesburg formation of the Nittany Arch region, Pennsylvania (area 1) bears the typical Mid-continent *Elvinia* fauna with a few new elements added. Just below this the member bears a new trilobite faunule which shares a few genera with the overlying *Elvinia* assemblage but finds its fullest development in the lower Conococheague limestone of the Shenandoah-Cumberland Valleys along the axis of the Upper Cambrian Appalachian geosyncline (area 2). Evidence is cited that this is a geosynclinal biofacies of the well-known *Elvinia* fauna.

The upper Ore Hill member contains a *Conaspis* fauna (middle Franconian) much like that of the standard Croixan area except for the Atlantic Province genus *Parabolinella*. Correlation of this fauna eastward into the geosyncline is as yet indefinite.

Descriptions of these faunas total 24 lower Franconian genera (six new) placed in 31 species (16 new). Five genera of the *Conaspis* fauna are described (one new) and these include eight species, half of which are new.

INTRODUCTION

AN INVESTIGATION of Upper Cambrian stratigraphy in the central Appalachians (the results of which are to be published later) afforded a collection of about 6000 trilobites. Most of these are of Franconian age and are herein described. Extensive criticism by Dr. C. O. Dunbar, Dr. Christina Lochman Balk and Dr. E. A. Frederickson is gratefully acknowledged. The work is part of a thesis presented in partial fulfilment of requirements for the degree of Doctor of Philosophy at Yale University.

The strata examined crop out in two linear belts: (1) for about 70 miles along the Nittany Arch of south central Pennsylvania and (2) in the Cumberland and Shenandoah Valleys for about 70 miles in Pennsylvania, Maryland, West Virginia and Virginia approximately 50 miles south and east of the first area.

The Nittany Arch region contains numerous exposures of the Gatesburg formation, 1750 feet of orthoquartzite and various types of dolomite which have been cyclically deposited. The Gatesburg has been divided (chiefly by Butts, 1945, and by the writer, 1949, abstract) into the following members: a basal non-arenaceous dolomite (the Stacy), the lower sandy Gatesburg, the Ore Hill limestone-dolomite, the upper sandy Gatesburg, and the Mines dolomite.

Only the Ore Hill member is fossiliferous. The member may be as much as 200 feet thick but commonly only part of this is in a limestone facies, and north of Williamsburg, Pennsylvania is completely massive, dark, crystalline dolomite; south of the Everett Quadrangle, Pennsylvania most of the middle portion of the member is dolomite. The lowest beds of the member contain a dark crystalline, massive limestone bearing Franconian trilobite genera found elsewhere only in the Conococheague formation. Most of the Ore Hill limestone is typically thin-bedded and weathers into yellow-mottled blue-gray flagstones 1 to 4 inches thick. It is finely crystalline or aphanitic and when fresh quite black. This limestone bears scattered beds of intraformational conglomerate, a calcirudite the matrix of which is clastic limestone and the phenoclasts pinkish, irregular-shaped aphanitic pieces of limestone up to several inches in length. These beds are extremely fossiliferous and have furnished Franconian trilobites of the typical *Elvinia* assemblage in the lower and middle Ore Hill member (10 to 110 feet above the base) and a well defined *Conaspis* fauna in the uppermost beds. The first appearance of early orthoid brachiopods and the gastropod *Pelagiella* coincides with that of the conaspid trilobites.

The Conococheague formation of the

Cumberland and Shenandoah Valleys represents almost the total Upper Cambrian of this area. The formation is a dark massive limestone laminated with yellow weathering siltstone and dolomite layers ranging up to several inches in thickness. It bears algal stromatolites of various types and numerous beds of intraformational conglomerate, calcareous oolites, and pure pink limestone, Its thickness approaches 2000 feet. The formation varies little except for certain

Dellea saratogoensis (Resser)†
Eshelmania snoburgensis Wilson, n. gen., n. sp.*
Eshelmania convexa Wilson, n. sp.
Pseudosaratogia magna Wilson, n. gen., n. sp.*

* Species in common only with the *Pseudosaratogia magna* fauna at the base of the Ore Hill member.

† Species in common as well with the typical *Elvinia* fauna higher in the Ore Hill member.

The fauna occurs through 75 to 130 feet of dark, massive medium-grained crystalline limestone. Correlation of the few trilo-

TABLE 1.—RANGE IN FEET ABOVE BASE OF ORE HILL MEMBER

Species name	0–15	10–30	30–80	80–110	105–160	–200
Conaspis retractalabra						xxxx
Conaspis perseus				*CONASPIS*	xxx	xxxxxx
Taenicephalus shumardi				FAUNA	xxxxxxxxxxxxx	xxxx
Parabolinella occidentalis					xxxx	
Wilbernia sp.					xxxxxxxxxxxxx	xxxxxxx
Housia vacuna			xxxxxxxxxxxx	xxxxxxxxxxxx		
Camaraspis convexa			xxx	xxx		
Elvinia roemeri		TYPICAL	xxxxxxxxxxxx	xxxxxxxxxxxx		
Burnetia urania		*ELVINIA*	xxxxxxxxxxxx	xxxxxxxxxxxx		
Dellea saratogoensis		FAUNA	xxxxxxxxxxxx	xxxxxxxxx		
Pseudosaratogia bulbosa			xxxxxxxx			
Plataspella anatina			xxxxxxxx			
Kindbladia wichitaensis			xxxxxxxx			
Cheilocephalus buttsi			xxxx			
Xenocheilos spineum			xxxxxxxx			
Kyphocephalus ponderosus		xxxxxxxxxxxx	xxxxxxxxxxx			
Bynumina terrenda		xxxxxxxxxxxx	xxxxxxxxxxx			
Irvingella major		xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxx		
Drabia acroccipita		xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxx		
Cliffia lataegenae		xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxx		
Pinctus latus		xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxxxxx		
Deckera completa		xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxx		
Berkeia granulosa		xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxx		
Dellea suada	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxx		
Dellea butlerensis	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxx		
Deadwoodia duris	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxx		
Buttsia drabensis	xxxxxxxxxxxx	xxxxxxxxxxxx	xxxxxxxxxxx	xxxxxxxxxxxx		
Pseudosaratogia magna	xxxxxxxxxxxx	*PSEUDOSARATOGIA*				
Eshelmania snoburgensis	xxxxxx	*MAGNA* FAUNA				

sandy units. The most distinctive of these is formed of about 300 feet of buff-yellow dolomite, laminated limestone, and coarse-grained orthoquartzite occurring in the base of the formation in Pennsylvania and in the western belt of outcrops northward from Frederick County, Virginia. This unit is middle Dresbachian in age. About 75 to 500 (generally 300) feet above its top (high in the lower third of the Conococheague limestone) may be found a new trilobite fauna showing close relation to the lowest Franconian of the Ore Hill member of the Gatesburg formation.

Buttsia drabensis Wilson, n. gen., n. sp.†
Cheilocephalus (?) pygidium, sp. undet.†
Drabia curtoccipita Wilson, n. sp.*
Drabia sp. undet.

bites immediately overlying the *Pseudosaratogia magna* assemblage is doubtful. A new genus, *Crepichilella*, occurs 35 feet above *Pseudosaratogia magna*, *Stigmacephalus? distorta* and some undescribed trilobites (locality 47-27w.3). Rocks bearing all three of these forms may be equivalent to middle Franconian strata. The higher Conococheague contains trilobites of Trempealeauian age (saukinids, *Plethopeltis*, *Plethometopus*, *Stenopilus*).

Facies relation of Pseudosaratogia magna *fauna.*—Although the *Pseudosaratogia magna* fauna possesses but one genus in common with typical *Elvinia* fauna as developed over the Mid-continent region, it contains numerous species and genera in common with the *Elvinia* fauna as developed in

the Ore Hill member. These new genera from the Ore Hill are well represented farther east in the fauna of the lower Conococheague limestone.

The very lowest beds of the Ore Hill bear the *Pseudosaratogia magna* fauna mixed with a few genera of the *Elvinia* assemblage. About 15 feet above the base of the Ore Hill *Pseudosaratogia magna*, *Eshelmania snoburgensis* and *Drabia curtoccipita* disappear but *Buttsia drabensis* continues to mix with the higher, typical *Elvinia* fauna. *Drabia* and *Pseudosaratogia* are represented higher in the Ore Hill by different species. These and *Buttsia drabensis* occur most commonly in dark aphanitic or coarsely crystalline limestone rather than in the pinkish intraformational conglomerate of the middle Ore Hill which so commonly bears the typical Mid-continent *Elvinia* fauna.

While ranging through over 100 feet of beds in the Conococheague formation, the *Pseudosaratogia magna* fauna characterizes but 15 feet of the Ore Hill member. This fact, plus the local indications of lithofacies control of the fauna in the Ore Hill and the picture of regional west to east change in the *Elvinia* fauna mentioned above would indicate that environment in the lower Franconian sea effected a change in its trilobite fauna between central Pennsylvania and the Cumberland Valley. Evidently in earliest Franconian time trilobites of the *Pseudosaratogia magna* fauna dominated the central Pennsylvania area but later were largely replaced here by the more typical *Elvinia* fauna, their descendants mingling with this more western assemblage to some extent. No indication exists that the *Elvinia* fauna of the Mid-continent region reached the eastern part of the Appalachian geosyncline.

Regional study of Upper Cambrian stratigraphy in the central Appalachians shows that the Gatesburg and Conococheague formation lie in areas of different lithofacies and that the dolomite and coarse orthoquartzite of the former formation grade southeastward into the laminated silty limestone of the latter (Wilson, 1949, abstract). It is reasonable to assume that concomitant with this change in lithofacies a faunal change has also occurred.

LOCALITIES COLLECTED

ORE HILL MEMBER, NITTANY ARCH BELT

45-2w. ORE HILL QUARRY, abandoned quarry about ¼ mile east of cross roads of Pennsylvania State Highway 686 and a road leading east to Ore Hill; immediately south of the latter road; Bloomfield township, Bedford County, Pennsylvania. Type locality of Ore Hill limestone; partial section, unplaced stratigraphically.

45-2w.5, float near middle of Ore Hill, *Elvinia* fauna.

45-2w.4 and 2w.3, dark limestone near middle of Ore Hill member, about 25 feet above 2w.2, *Elvinia* fauna.

45-2w.2, dark limestone on quarry rim on west side, *Elvinia* fauna.

45-2w.1, float, lower than exposed beds in quarry, *Elvinia* fauna.

47-3w. DRAB on slopes north of and in a low road cut at south side of an asphalt township road ¼ mile west of Drab-Beavertown, northern Huntingdon Quadrangle, Pennsylvania.

	Feet above base of member
47-3w.29 (top beds in road cut, south of road), dark limestone, poorly developed fauna, *Pseudosaratogia magna* assemblage?	107
47-3w.28, pinkish intraformational conglomerate, *Elvinia* fauna	92
47-3w.26, dark aphanitic limestone, *Elvinia* fauna	72
47-3w.22, coarsely crystalline trilobite coquina, *Elvinia* fauna	57
47-3w.20, gray crystalline limestone, pinkish intraformational conglomerate, *Elvinia* fauna	49
47-3w.19, 47-3w.18, gray crystalline trilobite coquina and pinkish intraformational conglomerate, *Elvinia* fauna	48
47-3w.17, gray crystalline trilobite coquina, *Elvinia* fauna	44
47-3w.16, pinkish intraformational conglomerate, *Elvinia* fauna	41
47-3w.15, gray crystalline limestone, *Elvinia* fauna	39
47-3w.14a, *Hyolithes* bed, *Elvinia* fauna	38.5
47-3w.14, dark crystalline limestone, abundant *Hyolithes*, *Elvinia* fauna.	36
47-3w.6, float between 10 and 30 feet above base of member, *Pseudosaratogia magna* mixed with *Elvinia* fauna.	

47-5w. POTTER CREEK-SCOTT FISHER FARM. North side of Potter Creek, north of Scott Fisher farm; outcrop extending about ¼ mile, its upper part cut by Pennsylvania State Highway 868, just north of Maria, northwest Everett Quadrangle, Pennsylvania.

	Feet above base of member
47-5w.36, dark aphanitic pebble conglomerate, *Conaspis* fauna (south of creek, on bluff behind old house across creek from road cut outcrop)	152
47-5w.34, gray crystalline limestone with intraformational conglomerate, *Conaspis* fauna (north side of road cut)	146
47-5w.17, finely crystalline dark limestone, *Conaspis* fauna	105
47-5w.12, dark finely crystalline limestone, *Conaspis* fauna	90
47-5w.8a, crystalline limestone and pinkish intraformational conglomerate, *Elvinia* fauna	55
47-5w.5, brownish trilobite coquina in pinkish intraformational conglomerate, *Elvinia* fauna	36
47-5w.3, gray crystalline trilobite coquina with pinkish intraformational conglomerate, *Elvinia* fauna (Lower 20 feet of member cut off by fault 12 feet below)	32

47-6w. SOUTH OF POTTER CREEK. Along top of a ridge above and south of an old school house on Potter Creek, along property line bounding land owned by Miller; just above R. Ferry farmhouse. Section in two parts these separated by same small fault which cuts off base of section 47-5w north of creek.

	Feet above base of member
Part I, North of fault:	
47-6w.3, dark limestone ledges in a field north of main line of measurement, *Conaspis* fauna	190
47-6w.2, dark crystalline limestone, pinkish intraformational conglomerate, *Elvinia* fauna	91
47-6w.1, dark crystalline limestone, *Pseudosaratogia magna* fauna	11
Part II, South of fault:	
47-6w.4, dark aphanitic limestone at crest of wooded ridge west of log cabin occupied by Hawkenberry family, *Conaspis* fauna	162
47-6w.6, beds lying in wooded copse west from above mentioned wooded ridge, pinkish intraformational conglomerate, *Elvinia* fauna	77
47-6w.5, lithology as above, *Elvinia* fauna	68
base of section, dolomite ledges in wheatfield	

47-7w. CROSS ROADS. Fifty yards northwest of a cross roads on top of a wooded ridge above Potter Creek, ½ mile southwest of juncture of a country road with Pennsylvania State Highway 868, north of Maria, northwest Everett Quadrangle, Pennsylvania.

	Feet above base of member
47–7w.1, coarsely crystalline limestone with pinkish intraformational conglomerate, *Conaspis* fauna	132

47-8w. FLUCHT-ESCHELMANN QUARRIES. On and south of a county road connecting Lafayetteville with Pennsylvania State Highway 868, northern Everett Quadrangle, Pennsylvania. Part I, in ledges behind Flucht place, ¼ mile

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EXPLANATION OF PLATE 89

FIGS. *1, 2—Berkeia typica* Resser, dorsal and profile views, ×4, of plaster cast of syntype no. 22285, Columbia Univ. Collections in Amer. Mus. Nat. Hist., lower Franconia formation, Taylor Falls, Minnesota. (p. 624)

3–6—Berkeia granulosa Wilson, n. sp., *3–5*, profile, dorsal, and frontal views, ×4, of cranidium, YPM 18530, 47-20w.1; *6*, dorsal view, ×4, of type cranidium YPM 18591, 47-5w.8a. (p. 624)

7–11—Bynumina terrenda Wilson, n. sp., *7*, dorsal view, ×6, of cranidium with one attached free cheek, type, YPM 18556, 47-6w.5; *8, 9* dorsal view, ×6, and profile view, ×7, of cephalon, YPM 18555, 47-6w.5; *10*, dorsal view, ×6, of cranidium, YPM 18557, 47-3w.20; *11*, dorsal view, ×6, of pygidium, YPM 18554, 47-3w.22. (p. 628)

13–18—Burnetia urania (Walcott) *13*, dorsal view ×2, of cranidium, YPM 18540, 47-5w.8a; *14*, dorsal view, ×3, of pygidium, YPM 18570, 47-6w.5; *15*, dorsal view, ×2, of rubber cast of free cheek, YPM 18537, 47-3w.22; *16*, dorsal view, ×2, of clay cast of pygidium, YPM 18538, 47-8w.6; *17, 18*, profile and dorsal views, ×2, of cranidium, YPM 18572, 47-5w.8a. (p. 625)

12, 19–24—Buttsia drabensis Wilson, n. sp., *12*, dorsal view, ×4, of free cheek, YPM 18543, 47-3w.6; *19, 21*, dorsal and profile views, ×3, of type cranidium, YPM 18541, 47-3w.6; *20, 24*, frontal and dorsal views, ×4, of cranidium, YPM 18542, 47-3w.6; *22*, dorsal view, ×4, of pygidium, YPM, 18552, 47-20w.1; *23*, dorsal view, ×4, of pygidium YPM 18548, 47-16w.7. (p. 627)

1

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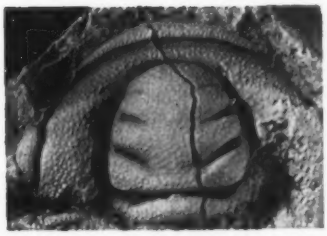
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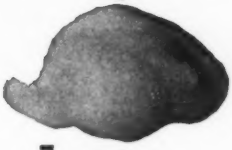
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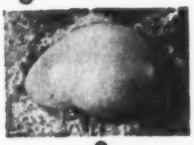
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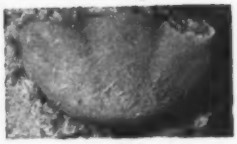
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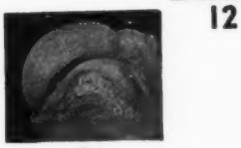
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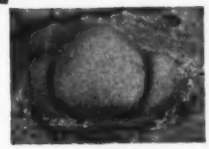
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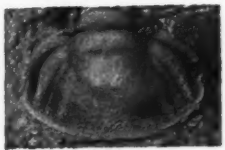
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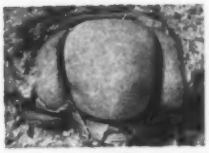
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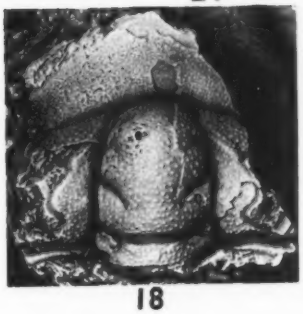
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Wilson, Central Appalachian Franconian trilobites

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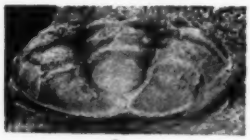
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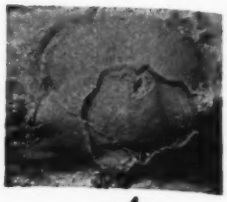
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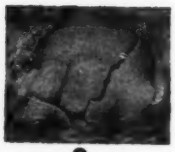
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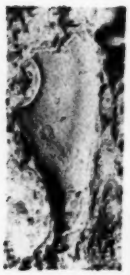
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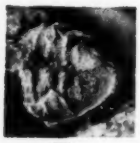
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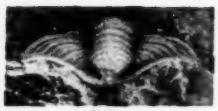
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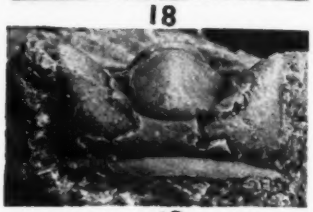
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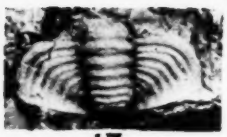
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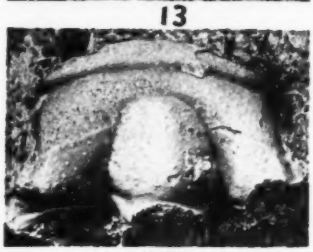
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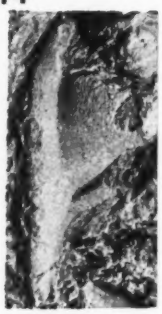
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Wilson, Central Appalachian Franconian trilobites

south of above mentioned county road on a former township road.

	Feet below top of member
47-8w.7, intraformational conglomerate with trilobite coquina, *Conaspis* fauna	20

Part II, ledges in orchard just north of country road from Eschelmann farmhouse.

	Feet above base of member
47-8w.3, float and 47-8w.1, massive hard limestone with cryptozoon stromatolite, *Pseudosaratogia magna* fauna	19
47-8w.2, float, limestone, genera of the *Elvinia* fauna known to occur also with the *Pseudosaratogia magna* fauna	11?

Part III in quarry owned by Snowburger across road from the Eschelmann farmhouse. Base of Ore Hill member in road cut below quarry.

	Feet above base of member
47-8w.6, pinkish intraformational conglomerate at top of quarry wall, *Elvinia* fauna	58.5
47-8w.4, crystalline limestone, *Elvinia* zone with species commonly found also below with *Pseudosaratogia magna*	45
47-8w.1a, dark massive, crystalline limestone, *Pseudosaratogia magna* fauna	11

47-10w. WEST OF WOODBURY. Two miles west of Woodbury, Pennsylvania atop the wooded ridge formed by Gatesburg formation, near old farm buildings and a large sink, northern Bedford County.

47-10w.6, dark platy limestone near top of member, *Conaspis* fauna

47-10w.5, dark platy limestone, *Orygmaspis* (?) sp. probably within 10 feet of top of member.

47-14w. RUINED FARMHOUSE. On hill top ¼ mile east of a gravel township road and ½ mile southwest of cross roads at 47-7w. In small ledges in a field near ruined farmhouse. Two and one half miles east of Lafayetteville, northwest Everett Quadrangle, Pennsylvania.

47-14w.1 near top of member, *Conaspis* zone

47-15w. FICKUS QUARRY. Abandoned quarry 2 miles south of Hartley on southeast edge of Everett Quadrangle, ¼ mile west of an asphalt county road between Bedford and Rainsburg, Pennsylvania.

	Feet above base of member
47-15w.5, dark aphanitic platy limestone, *Conaspis* fauna (in woods above small quarry)	165
47-15w.4, pinkish intraformational conglomerate, bed of *Lingulepis*, *Elvinia* fauna (in quarry wall)	46
47-15w.3, float from several feet above, dark aphanitic limestone, *Elvinia* fauna	35?
47-15w.2, aphanitic dark limestone, species of the *Elvinia* fauna known to occur with *Pseudosaratogia magna*	12

EXPLANATION OF PLATE 90

FIGS. *1–8*—*Camaraspis convexa* (Whitfield) *1*, dorsal view, ×4, of cranidium, YPM 18507, 47-5w.5; *2*, dorsal view, ×2, of cranidium, YPM 18505, 47-6w.5; *3*, *4*, profile and dorsal views, ×4, of cranidium, YPM 18503, 47-5w.5; *5*, dorsal view, ×4, of pygidium, YPM 18582, 47-5w.5; *6*, *7*, dorsal and profile views, ×4, of pygidium, YPM 18581, 47-5w.5; *8*, dorsal view, ×4, of free cheek, YPM 18504, 47-5w.5. (p. 630)

9—*Camaraspoides berkeyi* (Resser), dorsal view ×6, of small cranidium, YPM 18534, 47-5w.5. (p. 631)

10–17—*Deckera completa* Wilson, n. sp. *10*, dorsal view, ×2, of type cranidium clearly showing test, YPM 18565, 47-5w.8a; *11*, *13*, dorsal, oblique-lateral, and frontal views of cranidium, ×3, YPM 18564, 47-3w.19; *14*, dorsal view, ×4, of cranidium, YPM 18557, 47-5w.3; *15*, dorsal view, ×4, of free cheek, YPM 18568, 47-6w.6; *16*, *17*, posterior and dorsal views, ×4, of type pygidium, YPM 18566, 47-5w.8a. (p. 634)

18–24—*Cliffia lataegenae* (Wilson) *18*, dorsal view, ×6, of well preserved cranidium, YPM 18467, 47-5w.8a; *19*, oblique-lateral view, irregularly oriented to show position of palpebral lobe anterior to preglabellar furrow, ×6, cranidium, YPM 18473, 47-3w.19; *20*, *21*, frontal and dorsal views, ×4, of cranidium with more posteriorly located palpebral lobes, YPM 18470, 45-2w.2; *22*, dorsal view, ×6, of pygidium, YPM 18471, 47-3w.26; *23*, dorsal view, ×6, of cranidium with anteriorly placed palpebral lobes, large posterior limbs, YPM 18474, 47-6w.5; *24*, upright lateral view, ×6, of free cheek, YPM 18469, 47-3w.20. (p. 633)

25—*Dokimocephalus intermedius* (Resser), dorsal view, ×2, YPM 18489, 47-5w.8a. (p. 640)

Feet above base of member

47-15w.1, dark crystalline limestone, *Pseudosaratogia magna* fauna..... base

47-20w. IMLER QUARRY. Just to east of township road to east of Evitt's mountain, 2.5 miles south of junction of this road with Bedford-Rainsburg road at Egolf Park. Northwest corner of Clearville Quadrangle (Colerain Township), Pennsylvania.

Feet above lowest exposed beds of member

In face of wooded ridge, above quarry:
47-20w.2, dark platy limestone, *Conaspis* fauna..... 166
47-20w.6, dark platy limestone, *Conaspis* fauna..... 150
47-20w.5, dark platy limestone, *Conaspis* fauna..... 148
(middle part of section, massive light colored dolomite)
In small quarry at foot of ridge:
47-20w.3, massive dark crystalline limestone, *Elvinia* fauna..... 55
47-20w.1a, pinkish limestone pebble conglomerate, *Elvinia* fauna..... 53
47-20w.1, crystalline limestone at floor of quarry, *Elvinia* fauna..... 12
Probably about 30 feet more of member unexposed here.

CONOCOCHEAGUE LIMESTONE, CUMBERLAND-SHENANDOAH VALLEY BELT

Feet above basal sandy member

45-1w. WINCHESTER, VIRGINIA.
Part I, in field just east of a wooded ridge and south of a railroad spur about 1800 feet west of the southern outskirts of Winchester, Frederick County, Virginia.

45-1w.2, weathered limestone with *Pseudosaratogia magna, Drabia curtoccipita, Buttsia drabensis*..... 236

Part II, on a low hill ½ mile west of Winchester, Virginia city center, at city limits on U. S. Route 50 to south of highway and immediately west of the old Glen Burnie estate. Uppermost beds are exposed close to a rock wall and section proceeds westward up a low ridge (northern extension of ridge of part I) supported by basal sandy member of the formation.

Feet above basal sandy member

All dark medium-bedded oolitic limestone and dolomite:
45-1w.5, *Pseudosaratogia magna*..... 275
45-1w.6, *Pseudosaratogia magna, Buttsia drabensis, Drabia curtoccipita*.... 252
45-1w.3, *Pseudosaratogia magna, Buttsia drabensis, Drabia* sp. undet, *Drabia curtoccipita*..... 247
45-1w.2, *Dellea* (?) sp., *Pseudosaratogia magna, Drabia curtoccipita, Eshelmania snoburgensis*..... 228
45-1w.4, *Pseudosaratogia magna, Drabia curtoccipita, Eshelmania snoburgensis*..... 208
45-1w.8, *Pseudosaratogia* sp..... 143

47-16w. CUSHWA MILL. One-half mile southwest of Cushwa Mill, just south of a branch of Rockdale Creek and south of several farmhouses which lie north of the branch, north-central Williamsport Quadrangle, Maryland.

Low rise south of branch supported by basal sandy member of the Conococheague formation.

Feet above basal sandy member

47-16w.8, dark crystalline limestone, *Buttsia drabensis* and *Drabia* sp..... 117
47-16w.7, massive crystalline limestone, *Pseudosaratogia magna, Buttsia drabensis, Dellea saratogoensis Drabia* sp..... 106
47-16w.6, algal stromatolite, type of "*Cryptozoon undulatum*"..... 69.5
47-16w.4, *Pseudosaratogia* sp., *Buttsia drabensis, Eshelmania convexa*..... 48.5

47-23w. MUSSER FARM. Along north side of Conococheague Creek, in Musser farmyard 200 yards south of Pennsylvania State Highway 997 in eastern outskirts of Scotland, Chambersburg Quadrangle, Pennsylvania.

Basal sandy member of Conococheague exposed at farmyard, section extends west several hundred yards.

Feet above basal sandy member

47-23w.3, isolated ledge of dark limestone in field, *Buttsia drabensis, Drabia curtoccipita, Drabia* sp., *Pseudosaratogia magna*..... 410

47-27w. ANTIETAM BATTLEFIELD; fossiliferous beds of the section lie just west of axis of a syncline (between Smoketown road and East Woods) which crosses Mansfield Ave. about 250 yards east of Hagerstown Pike; basal sandy member of the Conococheague formation re-

duced to a few beds of hard silty dolomite with quartz weathering from it. This holds up a pronounced ridge east of Hagerstown Pike; West Woods also lies along it. Antietam Battlefield is just north of Sharpsburg, Maryland.

	Feet above basal sandy member
47-27w.3, (in a field just across fence at west side of road leading northward from monument marking spot where General Mansfield was killed), distorted somewhat platy limestone *Crepichilella antietamensis*	553
47-27w.2 (about 200 yards north of 27w.3 in rocks at edge of turn in above-mentioned road) *Pseudosaratogia magna*, undescribed trilobites not found lower in formation and *Crepichilella antietamensis*	518

47-28w. ROXBURY MILLS. On west side of a hill lying west of and across road from a large unpainted house standing just northwest of crossing of Antietam Creek at abandoned Roxbury Mills. Hill is supported by basal sandy beds of the Conococheague formation.

	Feet above basal sandy member
47-28w.2, dark crystalline, medium-bedded limestone, *Buttsia drabensis*, *Drabia curtoccipita*, *Pseudosaratogia magna*, fragmentary undescribed trilobites	306

SYSTEMATIC DESCRIPTIONS

Definitions of terminology.—In general recommendations of Howell et al. (1947) are followed in definition of parts of the cranidium and pygidium. Other terms requiring explanation are:

(1) palpebral lobe—thickened elevated border separated by the palpebral furrows from the fixed cheeks (palpebral rim of Ross, 1949).

(2) axial length of brim, border, glabella—measurements along longitudinal axis of cranidium ("width of brim and border" as used by Lochman, Frederickson et al. and "midlength" of Ross).

(3) elevation of fixed cheeks—following Lochman (1947, p. 60) cheeks are depressed, downsloping, horizontal, upsloping, or elevated; cheeks may also be broadly convex in profile if gently upsloping from dorsal furrow and downsloping distally.

(4) indentation of facial suture—trending sharply inward just in front of and/or behind the palpebral lobe.

(5) recurved posterior limbs—limbs whose distal margin is outwardly convex.

(6) measurements in furrows—measurements between features of the cranidium are made to the middle of the furrows separating them.

(7) brim:border ratio—axial length of the brim divided by axial length of the border.

(8) axial length ratio—axial length from the posterior end of the occipital ring to the front of the glabella divided by axial lengths of brim and border.

(9) width of fixed cheeks ratio—midwidth of the glabella divided by the width of fixed cheeks. Definition of these features follows Frederickson (see sketch, 1949, p. 342).

(10) ratio of glabellar taper—glabellar width at the occipital furrow or immediately anterior to it (whichever is greater) divided by the glabellar width measured along a line joining proximal ends of the ocular ridges.

Explanation of numbering system—All specimens numbered YPM are deposited in Yale University Peabody Museum, New Haven, Connecticut. Those numbered CW- . . . are also in Peabody Museum, but in the writer's collection. Localities are numbered by year (47-), by section (5w) and by stratigraphic level (.3); written 47-5w.3.

LOWER FRANCONIAN TRILOBITES

Genus BERKEIA Resser 1937

The genus *Berkeia* was erected by Resser (1937, p. 3) for a well-known species from a conglomerate bed of the lower Franconia formation at Taylor Falls, Minnesota, with a brief description and reference only to a sketchy free-hand drawing in the original publication. Resser (1942, pp. 79, 80, 90–94), without altering his original description, which applies only to the genotype, assigned the following species to the genus: *B. nevadaensis*, *B. affinis*, *B. comes*, *B. retusa*, *B. wichitaensis*, *B. angustata*, *B. jucunda*, *B. missouriensis*. (Cranidia of this

type have been assigned to *Kindbladia* by Frederickson, 1948, p. 802.) At the same time Resser also assigned *B. sculptilis* and *B. saratogoensis* to the genus. The former is considered a species of *Sulcocephalus* by Wilson and Frederickson (1951). Wilson (1949, p. 36) added the species *Berkeia glabellamersa* to the genus because of its relation to *B. saratogoensis*. The present paper places these last two species in the genus *Dellea* (see below) and adds a well represented new species from the Ore Hill member which is close to *B. typica*, the genotype. This species, plus recognition of the relation of *Berkeia* to the genus *Sulcocephalus* greatly alters the generic concept.

Two more lately added species of *Berkeia*, *B. lata* Frederickson 1949, and *B. occidentalis* Lochman 1950 remain to be studied in relation to the Ore Hill and topotype material and are now only provisionally accepted by this writer.

Generic diagnosis.—Glabella rather well-tapered, strongly furrowed, and convex, with occipital ring occupying at least 0.75 of axial length. Dorsal furrow in all species except the genotype excessively wide and deep, its variability of expression causing considerable difference in the convexity of the brim and sunken appearance of glabella. Brim downsloping and convex or reduced to a thin ridge by great depth and width of dorsal and marginal furrows. Brim:border ratio from 1 to 2, these structures varying in degree of convexity and in depth of marginal and dorsal furrows. Ocular ridges commonly present. Width of fixed cheek ratio from slightly more to slightly less than 2. Palpebral lobes are lateral or a little posterior to the glabellar midpoint. Posterior limbs are never far extended (less than distance across occipital ring), are moderately broad proximally and widely furrowed.

Facial suture intramarginal almost to center and proceeds straight back from anterolateral corner to palpebral lobe; posterior to palpebral lobe it indents in all species except *B. granulosa*. Pygidium not certainly known although Resser alludes to one in the original generic description. It is conjectured that plate 20, figures 3 and 4 (Berkey, 1898, p. 289) of "*Ptychoparia calymenoides*" is a thorax and pygidium of *B. typica*.

The following are brief characterizations of recognized species of *Berkeia*.

1. *Berkeia typica* Resser 1937, genotype: Lower Franconia formation, Minnesota: fixed cheeks less than half glabellar width, downsloping, glabella elevated above them; dorsal furrow well-defined but narrow. Shorter radius of curvature to marginal furrow than on other species. Brim:border ratio almost 1.5. (For other ratios see chart comparing this species with those of *Dellea*.) See plate 89, figures 1, 2.
2. *Berkeia granulosa* Wilson, n. sp.; Ore Hill limestone, Pennsylvania: closest to genotype, glabella deeply furrowed, moderately elevated, fixed cheeks a little more than half glabellar width, dorsal furrow very wide and deep, in this resembling species of *Sulcocephalus*. Brim:border ratio close to 1.
3. *Berkeia lata* Frederickson, 1949; Honey Creek limestone: small species with well-tapered glabella and fixed cheeks width ratio as low as 1. Border slightly tapered, its ratio with brim about 2. Frederickson compares this species with "*Berkeia*" *saratogoensis*. It is not as close to the genotype as the Ore Hill species but the very wide dorsal furrow removes it from "*B.*" *saratogoensis* and it is provisionally retained in *Berkeia*. *B. lata* seems close to *Pinctus latus* Wilson, n. sp. but the glabellas are very differently shaped.

Relations between the genera *Berkeia*, *Sulcocephalus*, and *Acrocephalites* are discussed below.

BERKEIA GRANULOSA Wilson, n. sp.
Plate 89, figures 3–6

Cranidium moderately large (averaging 10 by 18 mm. when fully adult), width over 1.5 times length, convex, great relief to individual parts. Glabella prominent, well-elevated, tapered to a broadly rounded front, in profile highly convex, steeply declining anteriorly; three pairs of oblique, well-incised glabellar furrows; dorsal furrow quite broad and deep, occipital furrow well-developed, a little deeper at sides, occipital

ring unadorned. Brim laterally downturned, unusually convex because of wide deep marginal and dorsal furrows, almost restricted to an elevated ridge, in most specimens centrally depressed so that a faint lateral swelling exists on each side of brim; border very convex and thick, evenly arched, ratio with brim a little over 1, tapering gradually laterally as brim expands. Fixed cheeks slightly convex or horizontal, their width ratio just less than 2; palpebral lobes moderate sized, kidney-shaped, centrally or just posteriorly located; ocular ridges well-defined; posterior limb broad at base and not far extended, very widely furrowed.

Free cheek unknown.

Facial suture intramarginal almost to center, proceeding straight back from anterolateral corner to palpebral lobe, behind which it trends out at about a 45° angle to longitudinal axis.

Entire surface of cranidium coarsely granulose.

Comparisons.—This species is close to *Sulcocephalus candidus* (Resser) and differs from it chiefly in having wide, flatter fixed cheeks, a normally tapered instead of posteriorly expanded and triangular border, and a slightly notched instead of normal brim. The species is close to *Berkeia typica* because its glabella is elevated, the frontal margin evenly arched, and because the fixed cheeks are slightly downsloping. *Berkeia granulosa* also resembles *Acrocephalites stenometopus* (Angelin). The general proportions of the cranidia are similar except for the brim-border relations, and the ornamentation is the same. The forms differ in that *A. stenometopus* has a more anteriorly placed palpebral lobe and a backward pointed instead of normal occipital ring. *B. granulosa* lacks the pointed triangular border of the European species and instead of the prominent central boss, its brim possesses commonly a faint central depression.

Occurrence.—*Berkeia granulosa* is found with the *Elvinia* fauna of the Ore Hill member. 47-3w.6; 47-5w.5, 5w.8a; 47-6w.5; 47-20w.1.

Type.—YPM 18591, cran., 47-5w.8a.

Other specimens: YPM 18530, cran., 47-20w.1.

Genus BURNETIA Walcott 1924

BURNETIA URANIA (Walcott)

Plate 89, figures 13–18

Ptychoparia (?) *urania* WALCOTT, 1890, U. S. Nat. Mus. Proc., p. 274, pl. 21, figs. 10, 11.

Burnetia urania (Walcott), WALCOTT, 1924, Smithsonian Misc. Coll., vol. 75, no. 2, p. 54, pl. 10.

Burnetia urania (Walcott), WALCOTT, 1925, idem, no. 3, p. 77, pl. 17, figs. 1–3.

Burnetia exilis RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 81, pl. 17, figs. 23–27.

Burnetia ectypa RESSER, 1942, idem., p. 82, pl. 17, figs. 30, 31.

Burnetia cava RESSER, 1942, idem, p. 83, pl. 20, figs. 1–3.

Burnetia pennsylvanica RESSER, 1942, idem, p. 84, pl. 21, figs. 29–31.

Burnetia urania (Walcott), FREDERICKSON, 1949, Jour. Paleontology, vol. 23, p. 348, pl. 70, figs. 12, 13.

Burnetia exilis Resser, FREDERICKSON, 1949, idem, p. 348, pl. 70, figs. 9–11.

The Ore Hill limestone furnished about 50 fairly well preserved specimens of this species, 20 of them complete enough to furnish ideas of the amount and types of intrapopulational variations expectable within species of *Burnetia*. These show considerable variation in degree of glabellar convexity, specimens alike in other regards ranging from a rather low profile (as in *Dokimocephalus*) to a highly arched one similar to that of the holotype. Forms with considerable convexity also show high and narrow fixed cheeks. The two pairs of glabellar furrows vary somewhat in their degree of expression. Little variation exists in the angularity of the palpebral lobes, width of fixed cheeks, narrowness of the posterior limb and axial length of the brim.

The most obvious variable is the axial length ratio which ranges from 1.6 to 2. This feature was compared on specimens from Oklahoma and Pennsylvania as follows:

(1) six Oklahoma specimens: measurements taken from photographs from Resser 1942 and Frederickson 1949; lengths of cranidia ranging from 29 to 12 mm.; mean of axial length ratios 1.69; standard deviation .24.

(2) 19 Pennsylvania specimens: measurements made on specimens; lengths of cranidia ranging from 6.5 to 19 mm.; mean of axial length ratios 1.83; standard deviation .30.

No correlation exists between size of the cranidia and axial length ratio; seemingly ontogeny may be eliminated as a cause for the variation. However, in general, specimens with low glabellar convexity have relatively longer axial lengths of brim and border giving lower axial length ratios (1.3 to 1.8) and expanded semicircular fronts to the cranidia. Specimens with high glabellar convexity usually have axial length ratios of 2 or more.

Almost the complete range of axial length ratios with attendant glabellar convexities is present within individual populations of *Burnetia* from beds 47-5w.8a and 47-5w.3. Since these specimens show variations of the same kind and degree used by Resser (1942) to designate species, the writer concludes that there is no valid basis for the latter's minute subdivision of the genotype, *Burnetia urania*.

Statistical comparison of the means of the axial length ratios of the Oklahoma species (*B. exilis* and *B. ectypa*) and the Pennsylvania forms shows no significant difference considering intrapopulational variation. The data fail to prove that the sample from the two formations could not have come from the same population, inferring that the axial length ratio is of no value in distinguishing species. Since it is linked to glabellar convexity and elevation of fixed cheeks, differences in these too are suspect as valid specific criteria within this genus. However, wide variations in this ratio may have biological significance since forms of *Burnetia* are known from Missouri (*B. alta* Resser) and the Rocky Mountain states which have extremely convex glabellas and greatly shortened brim and borders. These possibly comprise a valid species distinct from *B. urania*.

Free cheek.—The free cheek wide and well furrowed; ocular platform evenly downsloping and coarsely granulose; border about half width of ocular platform, smooth and somewhat concave medially, anteriorly bluntly tapered on dorsal surface though doublure extends untapered to center of anterior margin; posteriorly border prolonged into a long spine.

Pygidium.—Some differences exist between the pygidia associated with cranidia of *B. urania* in coquinas in the Ore Hill member and the pygidium from Texas assigned questionably by the writer in 1949 to *Dokimocephalus intermedius*. The former have a narrower axis with four axial rings and a posterior segment instead of only three segments. They have more obvious segmentation on the pleural lobes and a faint crease marks the slight downward flexure of the pleural lobes off the pleural platform. Otherwise the pygidia are similar.

Occurrence.—Rather common in the *Elvinia* zone of the Ore Hill limestone. 45-2w.2, 47-3w.15, 3w.22, 3w.28; 47-5w.3, 5w.5, 5w.8a (very common); 47-6w.2, 6w.5, 6w.6; and 47-8w.6.

Figured specimens.—YPM 18537, free cheek, 47-3w.22; YPM 18572, cran., 47-5w.8a; YPM 18540, cran., 47-5w.8a; YPM 18570, pyg., 47-6w.5; YPM 18538, pyg., 47-8w.6.

Genus BUTTSIA Wilson, n. gen.

Cranidium rather small (width across base from 5 to 10 mm.), subquadrate in outline excluding posterior limbs, width along base 1.5 times length, generally highly convex with great relief to component parts. Glabella most prominent, together with occipital ring occupying almost the total axial length, anteriorly rounded, tumid and inflated so that greatest width is considerably anterior to palpebral lobes; two pairs of faint glabellar furrows; dorsal furrow wide, deep and equally well defined throughout its course; occipital furrow distinct, occipital ring centrally thickened so that viewed dorsally it seems posteriorly directed, in profile view lying lower than glabella. Brim absent; dorsal furrow merges with a faint but distinct straight marginal furrow which anterolaterally separates fixed cheek from border; border distinct and rod-like, laterally untapered and almost overhung by glabella. Width of fixed cheeks ratio between 3 and 4, the cheeks being narrowest on a transverse line through glabellar midpoint (anterior to palpebral lobes), downsloping in all directions from dorsal furrow though not so much as sides of glabella; palpebral lobes of moderate size, beginning behind a point lateral to posterior glabellar furrow, set off from fixed cheek by a moderately well-defined furrow; posterior limbs rather bluntly triangular, only slightly

directed backward, widely and deeply furrowed, steeply deflexed ventrad.

Free cheek with ocular platform steeply deflexed on all sides of eye, its under surface marked with a line of fine pustules forming an arc below eye (fig. 12, pl. 89); border and doublure of cheek rather wide (half width of ocular platform), marginal furrow distinct; nothing known of anterior extension of doublure beyond point where facial suture turns under from dorsal surface; border has no genal spine but is slightly wider in genal angle.

Facial suture cuts anterior margin at anterolateral corner of cranidium and proceeds almost straight backward, encircles inconspicuous palpebral lobe and is directed outward and backward from this at about a 60° angle to longitudinal axis.

Pygidium assigned on basis of relative size and because it occurs only at stations where *Buttsia* cranidia are common. Though relative width and length may vary, pygidium generally as long as wide and spade-like; axis quite large and prominent, about 0.35 of total width, bears two rings and a posterior segment which may have two faint nodes; pleural platforms arched backward evenly to posterior margin, no anterolateral corners being present, slope very steeply down from axis and bear one well-defined segment with a strong pleural furrow and traces of a second segment, these being in addition to the thickened border which is more prominent anterolaterally; posterior margin of pygidium with a faint border, widely arcuate though posterolateral corners sharp.

Genotype: *Buttsia drabensis* Wilson, n. sp.

Comparisons.—*Buttsia* resembles several other Upper Cambrian genera in being a small form lacking a brim and possessing a large anteriorly inflated glabella, a triangular occipital ring and comparatively narrow fixed cheeks. Differences between these genera are as follows:

TABLE 2—GENERA SIMILAR TO *Buttsia*

Genus	Glabella	Glabellar furrows	Border	Posterior limbs	Location of pal. lobe
Acheilus	moderately inflated or cylindrical, overhangs border	well defined	no border, marginal furrow lacking	narrow at base	posterior to or opposite glabellar midpoint
Catillocephala	very inflated, overhangs border	no furrows	no transverse marginal furrow; border barely defined	broad at base	opposite glabellar midpoint
Hallaspis	slightly inflated anteriorly, block-like in form	well defined	well defined, narrow	broad at base	anterior to glabellar midpoint
Buttsia	moderately inflated anteriorly	faint furrows	well defined and rodlike	broad at base	posterior to glabellar midpoint

BUTTSIA DRABENSIS Wilson, n. sp.
Plate 89, figures 12, 19–24

Since only a single species is described, the generic description must contain particulars which are of only specific value and to this extent at least it will need modification.

Remarks.—Specimens of the species come from two different formations, but no discontinuous variations were noted except that specimens from the Conococheague limestone have somewhat stronger glabellar furrows. Some specimens from the Winchester section (e.g., those from 45-1w.3) show a decided flattening of the cranidium probably caused by deformation of the rock. A few cranidia from the Ore Hill member at the Drab section (47-3w.26) and all of those from 47-5w.8a at Potter Creek are moderately pustulose on both glabella and fixed cheeks, resembling in every other way the other material. Except for a faint occipital node on a single specimen from 47-16w.7 no other ornamentation was observed.

Occurrence.—A common member of the *Pseudosaratogia magna* fauna of the Conococheague limestone and associated with both this and the *Elvinia* fauna in the Ore Hill member. Not present with the *Conaspis* fauna and though unknown farther west is a good index to the lower Franconian of the central Appalachians. Ore Hill member: 47-5w.8a (common), 5w.5, 5w.3; 47-3w.29, 3w.28(very common), 3w.27, 3w.26, 3w.19, 3w.6(very common); 47-2w.5, 2w.1; 47-6w.6, 6w.5, 6w.2; 47-8w.1, 8w.3 (very common), 8w.4, 8w.6; 47-15w.2, 15w.1 (common) and 47-20w.1. Conococheague limestone: 45-1wa.2, 45-1w.3 (very common), 1w.3-60 feet, 1w.6 (common), 47-16.7 (very common), 47-23w.3 (very common), 47-28w.2 (very common).

Type.—YPM 18541, cran., 47-3w.6 (free cheek on same piece of rock YPM 18543). Other specimens: YPM 18542, cran., 47-3w.6; YPM 18548, pyg., 47-16w.7; YPM 18552, pyg., 47-20w.1.

Geuus BYNUMINA Resser, 1942

Bynumina resembles other genera of the kingstonid family in its small size, large glabella, shallow furrows and great cranidial convexity. It lacks the pointed frontal limb of others, possesses a better defined border and glabella than *Kingstonia*, and in general glabellar shape and brim-border proportions resembles *Ankoura*. The occipital furrow, which is well developed on the Missouri species, *Bynumina caelata* Resser, is only faintly visible on the Ore Hill species and, hence, its depth cannot be cited as a generic character (Resser, 1942, p. 58).

Bynumina has been found so far only with the *Elvinia* fauna. Resser's brief mention of phylogeny indicates that the genus *Bynumiella* is also of Franconian age. This was collected in the Canadian Rockies at localities bearing *Illaenurus* and *Platycolpus* and from formations not older than medial Franconian (Lyell and Sabine formations, Walcott, 1928, pp. 286, 291–294, 332) and possibly younger.

BYNUMINA TERRENDA Wilson, n. sp.
Plate 89, figures 7–11

Cephalon small (largest specimen 5.5 by 3 mm.), wider than long and flattened fusiform in shape, absence of well-defined structures making it almost featureless though smooth protuberances outline border, eyes, and to lesser extent glabella. Cranidium highly convex, glabella rounded, its ratio of taper 1.5 plus, in profile view rising steeply above occipital portion to crest above palpebral lobes, declining anteriorly less steeply. Dorsal furrow faint, almost disappearing toward front; occipital and glabellar furrows barely suggested on specimens with test preserved, easily visible

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EXPLANATION OF PLATE 91

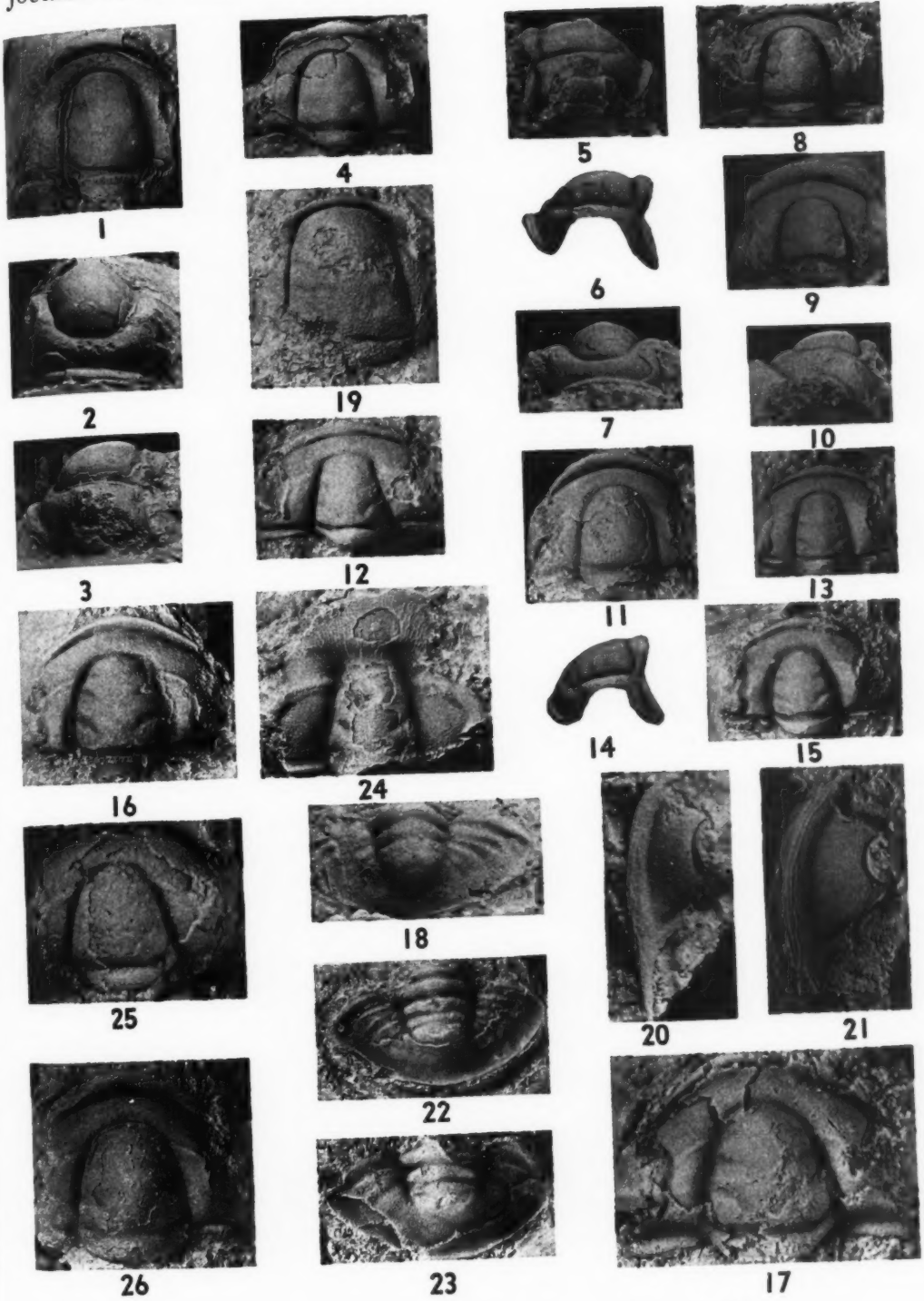
FIGS. *1–3, 11—Dellea butlerensis* Frederickson, *1–3*, dorsal, frontal, and profile views, ×2, of large cranidium, YPM 18422, 47-15w.2; *11*, dorsal view, ×3, of cranidium, YPM 18421, 47-3w.19 (p. 639)

4–10, 18, 20–23, 25, 26—Dellea suada (Walcott), *4, 5*, dorsal and profile views, ×2, of cranidium, YPM 18415, 47-5w.8a; *6–8*, profile, frontal, and dorsal views, ×4, of cranidium, YPM 18410, 47-5w.3; *9, 10*, dorsal and profile views, ×2, of cranidium resembling "*Asaphiscus*" ? cf. *florus* (Walcott), YPM 18403, 45-2w.4; *18*, dorsal view, ×6, of a pygidium which is more elongate and possesses a more pointed axis than normal, YPM 18412a, 47-5w.3; *20*, dorsal view, ×6, of free cheek, YPM 18412b, 47-5w.3; *21*, dorsal view, ×4, of free cheek, YPM 18417, 47-5w.8a; *22*, dorsal view, ×4, of pygidium, YPM 18402, 47-20w.1; *23*, dorsal view, ×4, of clay cast of pygidium, YPM 18413, 47-3w.26; *25*, plaster cast, dorsal view, ×4, of type cranidium, USNM 23860, loc. 70, Baldy Mountain, Burnet County, Texas; *26*, dorsal view, ×3, of large cranidium resembling "*Asaphiscus*" ? cf. *florus* (Walcott), YPM 18418, 47-3w.19. (p. 636)

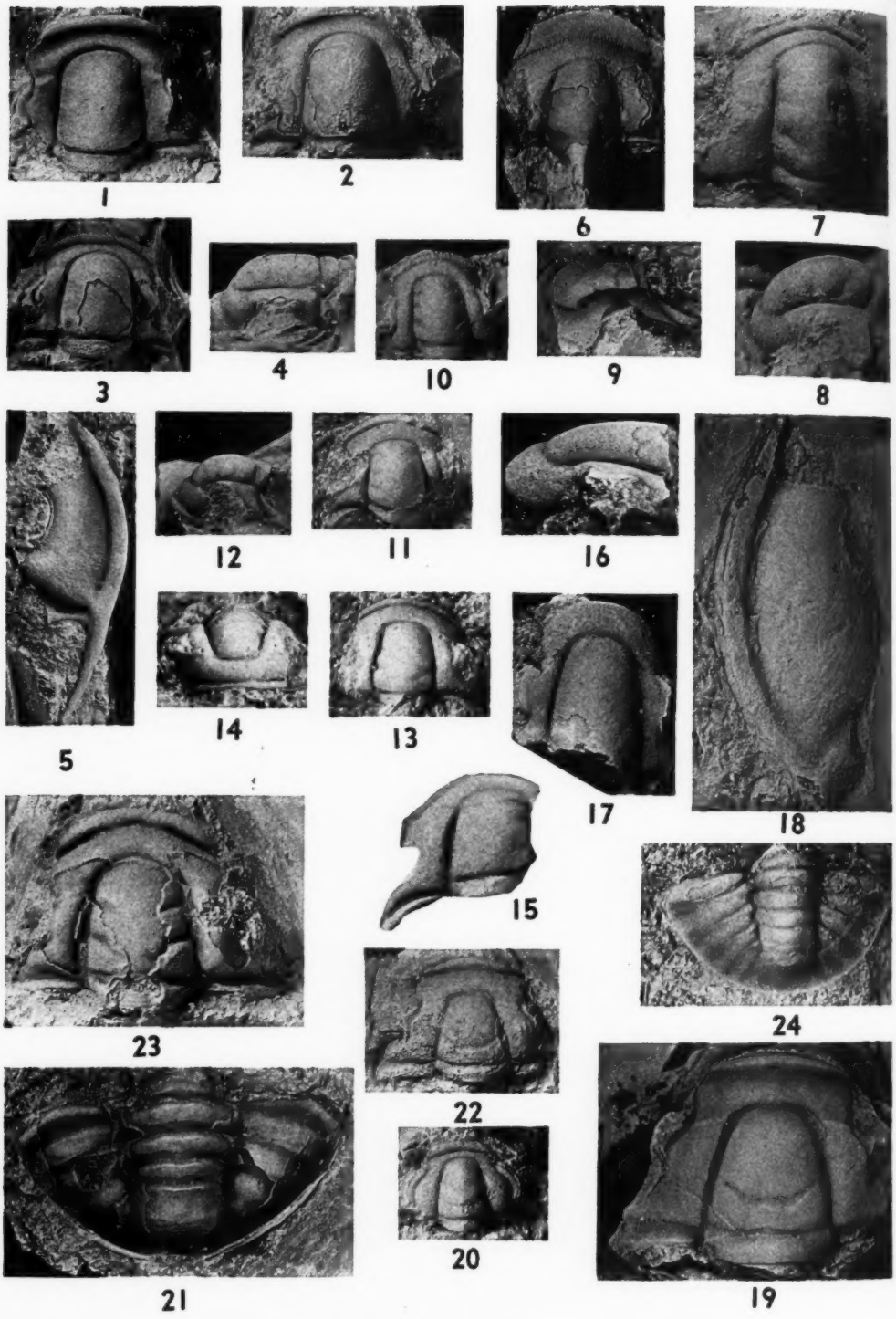
12–17—Dellea saratogoensis (Resser), *12, 14*, dorsal and profile views, ×6, of well preserved cranidium, YPM 18406, 47-5w.3; *13*, dorsal view, ×6, of cranidium, YPM 18434, 47-5w.8a; *15*, dorsal view, ×4, of internal impression of cranidium, YPM 18419, 47-5w.5; *16*, dorsal view, ×4, of internal impression of cranidium, YPM 18408, 47-16w.7; *17*, dorsal view, ×4, of topotype cranidium, CW-314, Greenfield, New York. (p. 638)

19—Cheilocephalus buttsi Resser, dorsal view, ×3, of cranidium, YPM 18515, 47-3w.19. (p. 631)

24—Pterocephalia sanctisabae Roemer, dorsal view of fragmentary cranidium, ×4, YPM 18559, 47-5w.8a. (p. 647)



Wilson, Central Appalachian Franconian trilobites



Wilson, Central Appalachian Franconian trilobites

on internal impressions, glabellar furrows sharply curved posterolaterally. Brim weakly defined, unflared laterally and deflexed; brim-border ratio about 1, border sharply tapered laterally. Fixed cheeks strongly downsloping, weakly defined from glabella but less than 0.35 its width along a line through center of palpebral lobes (this anterior to glabellar midpoint); width of fixed cheeks ratio not determinable since occipital furrow is too indistinct to enable accurate location of glabellar midpoint; palpebral lobes anteriorly located, merely faint lateral protuberances from fixed cheeks, no palpebral furrows being present; posterior limb well extended and untapered laterally, its base being about as broad as fixed cheeks are wide, slightly club-shaped owing to the peculiar course of the facial suture, proximally bearing a wide though shallow furrow which disappears distally.

Free cheek bearing a slightly elevated kidney-shaped eye, probably functionless since no ommatidia are visible, ocular platform curving smoothly ventrad from base of eye; wide border barely noticeable, not as well-defined as on cranidium, widening and becoming obscure at genal angle.

Facial suture intramarginal halfway to center (text-fig. 1), directed outward and backward to eye and proceeding above same, curving smoothly just below it and directed straight outward for some distance before curving gently posterolaterally and then sharply backward.

Pygidium almost semicircular, dorsal furrow very weak, failing to outline anterior end of axis; axis unelevated over pleural platform except for natural curvature of

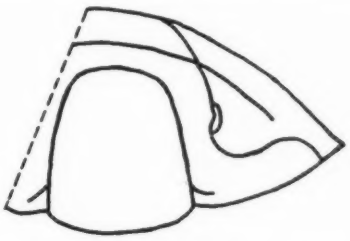


FIG. 1—Retouched camera lucida outline drawing of *Bynumina terrenda* Wilson, n. sp., approximately ×14. YPM 18556, 47-6w.5.

cranidium, composed of three or four broad, weakly defined segments; pleural lobes unsegmented, wider than axis, very slightly and evenly downsloping toward margin, then sharply deflexed; posterior margin completely rounded; border lacking.

Comparisons.—Specimens of *B. terrenda* were compared with a cast of the genotype, *B. caelata* Resser, from topotype material lent and identified as such by Dr. Franco Rasetti. The cast has a less distinct border but much better defined occipital ring and more deeply furrowed posterior limbs. The

EXPLANATION OF PLATE 92

FIGS. *1–5—Deadwoodia duris* (Walcott), *1*, dorsal view, ×3, cranidium, YPM 18599, 47-6w.5; *2*, dorsal view, ×3, cranidium, CW-190, 47-3w.19; *3, 4*, dorsal and profile views, ×2, of cranidium YPM 18500, 45-2w.3; *5*, dorsal view, ×3, of free cheek, YPM 18499, 45–2w.5. (p. 633)

6—Plataspella anatina (Resser), dorsal view, ×2, of cranidium, YPM 18533, 47-3w.22. (p. 647)

7, 8—Eshelmania convexa Wilson, n. sp., dorsal and profile views, ×12, of type cranidium, YPM 18488, 47-16w.5. (p. 642)

9–15—Eshelmania snoburgensis Wilson, n. sp., *9*, view from left front of fragmentary cranidium, ×4, YPM 18532b, 47-8w.1; *10*, dorsal view, ×4, of cranidium, YPM 18486, 47-8w.1; *11, 12*, dorsal and profile views, ×4, of type cranidium, YPM 18532a, 47-8w.1; *13, 14*, dorsal and frontal views, ×6, of cranidium, YPM 18487, 47-8w.1; *15*, dorsal view, ×8, of deformed cranidium, YPM 18485, 45-1w.3. (p. 642)

16, 17—Stigmacephalus ? distorta Wilson, n. sp., profile and dorsal views, ×4, of fragmentary type cranidium, YPM 18593, 47-27w.2. (p. 652)

18–22—Elvinia roemeri (Shumard), *18*, dorsal view, ×2, of free cheek, YPM 18496, 47-5w.8a; *19*, dorsal view, ×2, of cranidium, YPM 18493, 47-5w.8a; *20*, dorsal view, ×6, of very small cranidium (meraspid stage?), YPM 18492, 47-5w.8a; *21*, dorsal view, ×2, of pygidium YPM 18490, 47-5w.3; *22*, dorsal view, ×6, of very small cranidium, YPM 18491, 47-5w.3. (p. 642)

23, 24—Kindbladia wichitaensis (Resser), *23*, dorsal view, ×4, of cranidium, YPM 18529, 47-3w.20; *24*, dorsal view, ×4, of pygidium, USNM 62816, figured in 1916 by Walcott as *Asaphiscus ? florus*, probably assignable to *Kindbladia*, loc. 107v, 47-3w, Drab section. (p. 645)

eyes are located slightly more anteriorly in *B. caelata* and the ocular ridges stronger. The posterior limbs of *B. terrenda* are narrow and slightly recurved anteriorly whereas those of the topotype and Resser's figures of the holotype are proximally broad and taper evenly posterolaterally, the difference being due to the unusual course of the facial suture in the latter species.

Occurrence.—The genus *Bynumina* is a less well-known member of the *Elvinia* fauna. This species is found with that fauna in the Ore Hill member rather sporadically, commonly abundant when present; 45-2w.2; 47-3w.6, 3w.15, 3w.17, 3w.18, 3w.19, 3w.20, 3w.22 (common), 3w.26 (common); 47-5w.5; and 47-6w.5 (very common).

Type.—YPM 18556, cran. with one attached free cheek, 47-6w.5.

Other specimens: YPM 18554, pyg., 47-3w.22;YPM 18557, cran., 47-3w.20; YPM 18555, cephalon, 47-6w.5.

Genus CAMARASPIS Ulrich, 1924
CAMARASPIS CONVEXA (Whitfield)
Plate 90, figures 1–8

Arionellus (Agraulos) convexus WHITFIELD, 1879, Wisconsin Geol. Survey, Ann. Rept. for 1877, p. 57. Original reference to species.

Agraulos cushingi RUEDEMANN, 1916, New York State Mus. Bull., no. 189, p. 89, pl. 30, figs. 1, 2, 4.

Camaraspis convexus (Whitfield) Ulrich and Resser MSS, ULRICH, 1924, Wisconsin Acad. of Sci., Arts and Letters, vol. 21, p. 94.

Camaraspis cushingi (Ruedemann) RESSER, 1942, Smithsonian Misc. Coll., vol. 101, no. 15, p. 11.

Camaraspis convexa (Whitfield) FREDERICKSON, 1948, Jour. Paleontology, vol. 22, p. 798, pl. 123, figs. 12, 13. (Complete synonymy to date except for reference immediately above.)

Camaraspis convexa (Whitfield) WILSON, 1949, Jour. Paleontology, vol. 23, p. 33, pl. 10, figs. 6, 8, 11.

Comparisons.—The writer concurs with Frederickson that *Camaraspis cushingi* Resser is conspecific with the genotype. A small collection of topotype material of "*Camaraspis*" *cushingi* was furnished the writer by Dr. Franco Rasetti. These five cranidia and one pygidium show slightly varying degrees of convexity but the same depth of furrows and general proportions as the Ore Hill specimens. These latter are somewhat less convex than those from the lower beds of the Franconia formation of Wisconsin, but they are also smaller. They show a distinct occipital ring and the occipital furrow does not bifurcate laterally, thus differing from *Camaraspis plana* and *C. parabola* Frederickson.

Description.—The great abundance of *Camaraspis convexa* cranidia in several beds of the Ore Hill has made possible recognition of the attendant free cheek and pygidium.

Free cheek very simple, possessing a raised rim surrounding eyes and an evenly deflexed ocular platform whose surface is finely punctate. Marginal furrow very faint and rather wide; border ill defined but wide (about 0.65 width of ocular platform), steeply deflexed and tapered abruptly at both front and back extensions, thus making genal spine of only moderate length.

Pygidium quite wide with an appearance of being compressed longitudinally, a central indentation of posterior border giving it a flipper-like shape. Axis prominent, from 0.65 to 0.75 axial length but less than 0.35 its width, possessing two sharply elevated axial rings and a broad posterior segment excluding anterior half ring; axial rings may bear lateral nodes dorsally. Dorsal furrow wide and moderately deep; pleural platforms sloping up from it, arching and then steeply deflexed, in lateral profile showing their considerable elevation, possessing two easily visible segments and traces of one other. Anterior border proceeds straight out from edge and turns somewhat sharply posterolaterally to form an anterolateral corner, very sharp posterolateral corners lateral to end of axis; posterior margin with a very narrow border which is slightly indented and rises dorsad just behind end of axis, this being connected to it by a faintly defined ridge.

The pygidium is most common at a station furnishing a very large number of *Camaraspis convexa* cranidia (47-5w.5). It was also found by Dr. Franco Rasetti with numerous cranidia of the species at the railroad cut at Greenfield northwest of Saratoga Springs, New York.

Occurrence.—A common member of the *Elvinia* fauna; as in Texas and Wisconsin, very abundant where present; 47-3w.28; 47-5w.3, 5w.5 (very common), 5w.8a.

Figured specimens.—YPM 18507, cran.,

47-5w.5; YPM 18505, cran., 47-6w.5; YPM 18503, cran., 47-5w.5; YPM 18582, pyg., 47-5w.5; YPM 18581, pyg., 47-5.5; YPM 18504, free cheek, 47-5w.5.

Genus CAMARASPOIDES Frederickson 1949
CAMARASPOIDES BERKEYI (Resser)
Plate 90, figure 9

Agraulos convexus Whitfield, BERKEY, 1898, Am. Geologist, vol. 21, p. 288, pl. 20, figs. 9–11; pl. 21, figs. 3, 7.

Agraulos convexus Whitfield var. A, BERKEY, 1898, Am. Geologist, vol. 21, p. 288, pl. 20, figs. 1, 2; pl. 21, fig. 5.

Modocia berkeyi RESSER, 1935, Smithsonian Misc. Coll., vol. 93, no. 5, p. 42.

Camaraspoides berkeyi (Resser) FREDERICKSON, 1949, Jour. Paleontology, vol. 23, p. 349, pl. 68, figs. 1–9.

Frederickson has pointed out the similarity of this species to species of the genus *Camaraspis*. The writer, after examination of topotype material, concludes that proportions are the same in both genera, the only essential difference being that all furrows are consistently much deeper on *Camaraspoides*. The validity of this form is proved by its wide geographic distribution. It can be demonstrated that the depth of furrows in *Camaraspoides* is not the result of only the internal impression being known. The Ore Hill specimen, which has the test preserved, possesses well-marked furrows.

Occurrence.—The collections from the Ore Hill member furnished one cranidium with fragments of *Camaraspis convexa:* 47-5w.5.

Figured specimen —YPM 18534, cran., 47-5w.5.

Genus CHEILOCEPHALUS Berkey 1898
CHEILOCEPHALUS BUTTSI Resser
Plate 91, figure 19

Cheilocephalus buttsi RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 36, pl. 11, fig. 6.

Supplementary description.—Cranidium moderately convex, considerable relief to individual parts. Glabella plus occipital ring occupying over 0.9 of cranidial length (not all of it as stated by Resser), highly convex and steeply deflexed anteriorly, slightly tapered and rounded anteriorly but on the whole truncate; three pairs of glabellar furrows faint but slightly deeper than on other species; dorsal furrow distinct; occipital ring comparatively narrow but otherwise normal. Brim absent in front of glabella, restricted to lateral areas anterior to ocular ridges; border a sharply upturned, convex and arcuate band; anterolateral corners of cranidium sharper than in genotype. Fixed cheeks narrow and downsloping; palpebral lobes small, upturned and located just lateral to middle glabellar furrow anterior to midpoint of glabella; posterior limbs broad at base, bluntly tapered and well furrowed.

Ornamentation evenly granulose on all parts of cranidium.

Free cheek unknown.

Discussion.—The writer's collections furnished only a single cranidium lacking complete posterior limbs but supplementing Resser's material on which the border was destroyed. The right posterior limb on Resser's photograph of the holotype has been trimmed inaccurately. The convexity of the glabella and sharply upturned palpebral lobes and border distinguish this species.

Occurrence.—Very rare in the Ore Hill member. One specimen found at 47-3w.19 in the Drab section which also furnished the holotype (U. S. National Museum loc. 107v).

Figured specimen.—YPM 18515, cran., 47-3w.19.

CHEILOCEPHALUS sp. undet.
Plate 95, figures 6, 7

Common association of this type of pygidium with *Cheilocephalus* cranidia in the Welge sandstone of Texas is the basis for its assignment. Disparity in size coupled with rare occurrence in the Ore Hill would make an assignment to *Cheilocephalus buttsi* Resser doubtful.

Large and convex pygidia with little relief to parts (greatest individual 35 mm. wide and 25 mm. long). Axial width about 0.2 that of pygidium and its length about two-thirds total; axis unelevated but differentiated from pleural platforms by faint dorsal furrow, well tapered and bearing six flat rings and a small terminal segment. Pleural platforms very faintly segmented except for a large well-defined anterior segment, greatly elevated, posteriorly deflexed to a broad concave area which bears only a thin border along its margin.

Occurrence.—Rare with the *Elvinia* fauna of the Ore Hill member and possibly present in the *Pseudosaratogia magna* fauna

of the Conococheague limestone; 45-1w.6?; 47-28w.2?; 45-2w.3; 47-3w.26; and 47-5w. 8a.

Figured specimen.—YPM 18600, pyg., 45-2w.3.

Genus CLIFFIA Wilson, n. gen.

Cranidium small (largest 10 mm. across base; average 6 mm. basal width; 4 mm. axial length), more convex laterally than anteriorly and much narrower anteriorly than at base, relief of individual parts very great. Glabella sunken, moderately convex, almost as wide at base as long, truncate anteriorly though somewhat rounded at anterolateral corners, in profile not deflexed but evenly downsloping from back to front; three pairs of glabellar furrows, anterior one almost invisible, the posterior two unusually wide and deep, oblique, and slightly curved backward proximally; occipital furrow much deeper laterally than across axis, occipital ring centrally widened, bearing a well-developed node; dorsal furrow also wide and deep. Brim along axis equals width of fixed cheek, very convex, deflexed anterolaterally with a prominent median boss; marginal furrow deep; border thick, convex in both directions, strongly tapered laterally, brim: border ratio about 1.35. Fixed cheeks may vary from gently convex to steeply upsloping, width of fixed cheek ratio about 2; palpebral lobe anterior, small, semicircular, and either horizontal or upturned; ocular ridge wide and prominent; posterior limbs greatly extended, quite broad proximally, strongly deflexed but extended almost straight out, grooved by a wide, deep, and laterally expanding furrow.

Free cheek with a very small anteriorly placed eye, posterior margin about twice length of anterior margin, ocular platform dropping with a slight arch down to well-developed marginal furrow. Border about 0.25 width of ocular platform, anterior extension unknown, widened at genal angle and extended into an abruptly tapered genal spine.

Facial suture possibly intramarginal completely to center, proceeding backward, slightly outward, and commonly upward at a greater than 45° angle from anterolateral corner to elevated palpebral lobe behind which it trends far outward in a wide arc and cuts posterior margin at a distance from glabella equal to its basal width.

Pygidium assigned chiefly on basis of association; commonest at localities with abundant specimens of this cranidium, in most instances all other cranidia having been eliminated on a size basis. The cranidium and this pygidium have in common small size, well-developed furrows, great convexity, and a distinct node on segments. Pygidium blunt spearhead in shape; axis comparatively long and narrow (0.25 of width of pygidium), well defined by dorsal furrow which shallows posteriorly, with eight axial rings and a posterior segment (smaller specimens showing only six or seven axial rings); pleural lobes steeply deflexed with at least six segments visible, these without pleural furrows; pleural extension of half ring geniculate but rest of pleural segments evenly arched; border lacking and interpleural grooves extended completely to margin.

Genotype: *Acrocephalites lataegenae* Wilson 1949.

Discussion.—Specimens representing this genus from Dinwoody Canyon, Wind River Range, Wyoming (lent by Christina L. Balk) were identified as *Acrocephalites* and referred to by Howell and Lochman (1939, p. 115) as correlating the *Elvinia* zone of North America with the zones of *Lejopyge laevigata* and *Agnostus pisiformis* of Sweden. "*Acrocephalites*" *lataegenae* Wilson (1949, p. 31) was described from Texas from one small fragmentary cranidium, now the type of the *Cliffia* genotype. Much more complete material of this form from the Ore Hill member indicates several important differences from *Acrocephalites stenometopus* which is now better known following Westergård's redescription in 1948. These are: (1) the border of *Cliffia* has no anteriorly protruding spine or cusp; (2) its fixed cheeks are upsloping instead of horizontal; and (3) the more forward position of the eye in *Cliffia* results in broad-based, extended posterior limbs rather than the shortened ones of *Acrocephalites*. The pygidia assigned to these forms are also very different.

The two genera possess in common the depth of furrows, median boss, heavy ocular ridges, small semicircular palpebral lobes, and granulose ornamentation.

CLIFFIA LATAEGENAE (Wilson)
Plate 90, figures 18–24

Acrocephalites lataegenae WILSON, 1949, Jour. Paleontology, vol. 23, p. 31, pl. 10, fig. 14.

The original specific description was based upon the one known Texas cranidium which lacked complete fixed cheeks and palpebral lobes. Disregarding these unknown features it differs from the Pennsylvania material only in having coarse pustules on the brim and these forms are considered conspecific with it. The Ore Hill specimens demonstrate continuous intrapopulational variation in position and elevation of the eye. The palpebral lobes may lie lateral to the second glabellar furrow on only slightly upsloping fixed cheeks. Or, as on specimens from 47-3w.19 and other stations, the upturned lobes may lie on steeply upsloping fixed cheeks and be centered on a transverse line through the preglabellar part of the dorsal furrow. Forms with such anteriorly placed eyes possess broader, more extended posterior limbs.

The species possesses fine pustules (occasionally absent) which may form anastomosing rows on the brim and free cheek. Coarse pustules may be present on the brim.

Occurrence.—Common in the *Elvinia* fauna of the Ore Hill member, rare in the same zone in Texas, Wisconsin and Wyoming; 45-2w.2; 47-3w.6, 3w.14, to 3w.17, 3w.19 (common), 3w.20, 3w.22, 3w.26 (common), 3w.28; 47-5w.3 (common), 5w.5, 5w.8a (common); 47-6w.5, 6w.6; 47-2w.1; 47-8w.6 (common); 47-20w.1 (common).

Type.—CW-35, Sta. 42-13w.6, Camp San Saba section, Texas.

Figured specimens.—YPM 18471, pyg., 47-3w.26; YPM 18467, cran., 47-5w.8a; YPM 18473, cran., 47-3w.19; YPM 18470, cran., 45-2w2; YPM 18469, free cheek, 47-3w.20; YPM 18474, cran., 47-6w.5.

DEADWOODIA DURIS (Walcott)
Plate 92, figures 1–5

Asaphiscus ? duris WALCOTT, 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 392, pl. 63, figs. 8, 8a.

Dunderbergia ? declivita MILLER, 1936, Jour. Paleontology, vol. 10, p. 30, pl. 8, figs. 37, 38.

Deadwoodia duris (Walcott), WILSON, 1948, Jour. Paleontology, vol. 22, p. 33, pl. 8, figs. 9–17.

The Ore Hill member furnished many more specimens of this species and additional information to that of 1948 when the writer restudied it. *Deadwoodia duris* is a moderate-sized trilobite (maximum cranidial length about 1 cm.). Most of the specimens possess the preglabellar platform so characteristic of the species although some resemble *D. panope*, the genotype, in lacking it. Since the platform is better developed in larger specimens (which also show more steeply deflexed brims and more prominent, deeper furrowed glabellas), and since poor development of the platform may be a consequence of later flattening of the carapace, some doubt exists as to the specific distinctness of *D. duris* and *D. panope*. A study of populations of the genotype is necessary to prove this one way or the other.

Description of free cheek.—Free cheek with a rather large eye surrounded and underlain by a thickened rim elevated and distinct from ocular platform. Ocular platform in two parts: proximal portion horizontal then sloping smoothly down to depressed portion just proximal to border; distal portion (including sloping area) about three times width of proximal part which represents a continuation of flat fixed cheeks. Border very clear-cut and thickened, comparatively narrow, far-extended and tapered anteriorly; posteriorly projected into a long, slightly incurved spine; border unthickened into genal angle although deep furrow of posterior limb is separated from sunken marginal furrow by a rounded ridge off the elevated portion of ocular platform which merges with border at genal angle. Ocular platform covered with fine radiating and anastomosing striae and some fine granulation.

It is believed on the basis of association that the *Deadwoodia* pygidium is closely similar to if not identical with that assigned to *Dellea* although the prevalence of the associated parts does not enable certain identification.

Deadwoodia duris may be readily distinguished from species of *Dellea*, which it resembles in its brim-border relations and proportions of the fixed cheeks, by (1) the preglabellar platform, and in the absence of that, (2) by the large, less tapered, quadrate glabella, and (3) flat fixed cheeks.

Occurrence.—Common in the *Elvinia* fauna of the Ore Hill member; 45-2w.3,

45-2w.5; 47-3w.6 (?), 3w.16–18, 3w.19 (very common), 3w.20 (common), 3w.22 (common), 3w.26, 3w.28; 47-5w.5; 47-6w.5; 47-8w.6; 47-15w.2, 15w.3; 47-20w.1.

Type.—U. S. Nat. Mus. 62818, cran., loc. 107E, Ore Hill Quarry, 45-2w.

Figured specimens.—YPM 18599, cran., 47-6w.5; YPM 18500, cran., 45-2w.3; YPM 18499, free cheek, 45-2w.5; CW-190, cran., 47-3w.19.

Genus DECKERA Frederickson 1949

DECKERA COMPLETA Wilson, n. sp.

Plate 90, figures 10–17

Cranidium like that of *Deckera aldenensis* Frederickson, the genotype, with following exceptions: (1) brim-border ratio from 1 to 1.3 instead of about 2. That this may be a common measurement in the genus is evinced by a ratio of about 1 in a fragmentary cranidium of the genus from Texas. (2) Elevated fixed cheeks rise at an angle greater than 25° above dorsal furrow; estimated at about 35°. (3) Ornamentation is present on the glabellar slopes.

Ornamentation differs on the outer and inner surfaces of the test, the outer surface showing everywhere a mat of fine granulation in which are set numerous coarse pustules absent only in furrows of the cranidium. On exfoliated specimens the internal impression shows the pustules alone, indicating that the test as a whole was elevated to form them.

The facial suture on the Ore Hill species is directed as in the genotype and it is expected that the free cheeks would be closely similar, if not identical, in the two species. The tapering of the border indicates that the facial suture leaves the dorsal surface about halfway between the anterolateral corner and the center.

Free cheek with steeply deflexed ocular platform whose margin anterior to eye is much more extensive than that along posterior limb; marginal furrow wide; border quite wide and thickened, about 0.5 width of ocular platform, anterior extension tapered abruptly on dorsal surface, prolonged posteriorly into a long thick genal spine. Typical finely granulose ornamentation on ocular platform but no pustules.

The pygidium is assigned to the species because it was found only at localities with abundant cranidia of *Deckera completa*, being most common in coquinas in which this cranidium was the most abundant form of comparable size. The finely granulose ornamentation of the pygidium matches that of the cephalon.

Pygidium highly segmented, quadrate in outline with antero- and posterolateral corners somewhat rounded, dorsal furrow wide, outlining prominent cylindrical axis which extends completely to posterior border and bears seven segments excluding anteriormost half ring. Pleural lobes slightly convex, with three segments each bearing a pleural furrow almost as strong as the interpleural grooves; only traces of a fourth pleural segment; the posterior three axial rings possess no corresponding pleural segmentation. Pleural segments trending first straight out, bending abruptly posterolaterally at a 45° angle about halfway on their course. Outer portion of pygidium flexed upward and separated from pleural platforms by a very wide groove making posterolateral portion of pygidium auriculate; on this portion the segmentation fades out. Posterior margin deflexed considerably at end of axis placing this feature in a decided trench; a suggestion of a border present here only. Surface finely granulose but lacking pustules. The intense segmentation and auriculate pleural lobes are distinguishing characteristics.

Occurrence.—Common with the *Elvinia* fauna of the Ore Hill member; 45-2w.2; 47-3w.6, 3w.17, 3w.19 (common), 3w.20, 3w.22, 3w.26 (common) 3w.28; 47-5w.3 (common), 5w.5, 5w.8a; 47-6w.5, 6w. 6 (common); 47-8w.6 (common); 47-15w.2, 15w. 3; 47-20w.1 (very common).

Types.—YPM 18565, cran., 47-5w.8a; YPM 18566, pyg., 47-5w.8a. Other specimens: YPM 18564, cran., 47-3w.19; YPM 18557, cran., 47-5w.3; YPM 18568, free cheek, 47-W.6.

Genus DELLEA Wilson 1949

Hundreds of specimens representing this genus in the Ore Hill limestone make it necessary to amend the original generic description (Wilson, 1949, p. 34).

Revised description.—Cranidium quite convex, averaging about 5 mm. long though specimens up to 1 cm. long are known; the

width about 1.5 times length. Glabella prominent, elevated, in most species anteriorly tapered, this ratio being about 1.4. Dorsal furrow varying specifically from shallow but well-incised to moderately wide. Glabellar furrows also specifically variable in depth, in one species being almost absent, in another moderately well-incised, and in the genotype faintly impressed. In the several populations studied the mean axial length ratios fell between just under 3 and 3.5 with a standard deviation of 0.5 and

shape of glabella, and general type of brim and border have been considered of generic importance by most recent Cambrian trilobite taxonomists. It seems quite possible to the writer that there may exist trilobite stocks which have evolved along other lines than these. It is his view that the species *Berkeia typica*, *B. granulosa* and *Sulcocephalus candidus* represent a distinct line of descent from that composed of *Dellea suada*, *"Berkeia" saratogoensis* Resser, *"Berkeia" glabellamersa* Wilson, and several other

TABLE 3.—MEANS AND STANDARD DEVIATIONS IN POPULATIONS OF *Dellea* AND *Berkeia*

Population	Ratios			
	Axial length	Glabellar taper	Width of fixed cheeks	Brim: border
Dellea suada, topotypes, 42-9w, Baldy Mt., Texas, 5 specimens	M—2.7 σ — .17	M—1.5 σ — .094	M—2.6 σ — .44	M—1.7 σ — .45
Dellea suada, 47-5w. 8a, Potter Crk, Penn., 21 specimens	M—3.6 σ — .50	M—1.4 σ — .125	M—3.1 σ — .76	M—1.5 σ — .56
Dellea suada, 47-5w.3—5w.5, Potter Creek, Penn., 23 specimens	M—3.4 σ — .56	M—1.45 σ — .16	M—2.85 σ — .60	M—1.65 σ — .47
Dellea saratogoensis topotype (including original types), Greenfield, N. Y., 13 specimens	M—2.8 σ — .15	M—1.4 σ — .15	M—2.6 σ — .39	M—2.2 σ — .69
Dellea saratogoensis, 47-16w.7, Conococheague limestone, Maryland, 9 specimens	M—3.3 σ — .52	M—1.35 σ — .03	M—2.7 σ — .38	M—2.4 σ — .47
Dellea saratogoensis, 47-5w.3—5w.5, Potter Creek, Penn., 9 specimens	M—2.9 σ — .225	M—1.4 σ — .12	M—2.3 σ — .20	M—1.5 σ — .40
Dellea glabellamersa, 42-9w, Baldy Mt., Texas, 7 specimens	M—3.35 σ — .70	M—1.4 σ — .18	M—1.9 σ — .18	M—1.7 σ — .14
Berkeia typica, topotype, Taylor Falls, Minn., 4 specimens	M—3.6 σ — .154	M—1.35 σ — .18	M—2.25 σ — .19	M—1.4 σ — .15

M—mean.
σ—standard deviation.

under. Border arcuate, radius of curvature of marginal furrow being about the same on all species; on an average size cranidium of 5 mm. it varies from 3 to 5 mm., averaging 4 mm. Brim steeply deflexed and specifically variable in its slight convexity; mean brim: border ratios in seven populations vary from 1.5 to 2.4 with standard deviations of not over 0.70. This ratio is highly variable even in forms of the same species. Width of fixed cheek ratio varies specifically (see below) ranging approximately from 2 to 3.

Genotype: *Dellea suada* (Walcott) = *Dellea wilbernsensis* Wilson.

Comparison of Dellea *and* Berkeia.—Differences in width of fixed cheeks, axial length ratios, position of palpebral lobes,

species. This is despite the fact that many of the characters used to separate these two groups have been considered only of specific importance in other Upper Cambrian trilobites.

The *Berkeia-Sulcocephalus* group of trilobites differs from the *Dellea-"Berkeia" saratogoensis* forms in having deeper dorsal and glabellar furrows (even on external test surfaces), and a more convex brim. The brim: border ratio in the former group is generally less than 1.5, commonly approaching 1, with a low standard deviation, whereas in the *Dellea* group the ratio is much more variable, commonly approaching 2 (see table 3).

The posterior limbs are less extended on

the former group and are more widely furrowed. This group also tends to be coarsely pustulose.

The chart of specific population ratios above indicates that there is not significant difference in axial length, glabellar taper, or width of fixed cheek ratios between the two groups. Similarly the palpebral lobes are medial on both forms and the glabellas are similarly shaped.

The species of *Dellea* described below have all been discovered in Texas, Oklahoma, Pennsylvania, and in part in Wisconsin sections of the *Elvinia* zone. Such widespread and consistent association indicates to the writer that these are valid species rather than geographically controlled subspecies.

DELLEA SUADA (Walcott)
Plate 91, figures 4–10, 18, 20–23, 25, 26

Ptychoparia suada WALCOTT, 1890, U. S. Nat. Mus. Proc., vol. 13, p. 274, pl. 21, fig. 9.
Asaphiscus ? florus WALCOTT, 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 392 (in part), pl. 63, figs. 6 and 6a.
Asaphiscus ? cf. *florus* WALCOTT, 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 393, pl. 63, fig. 7.
Dunderbergia suada (Walcott) RESSER, 1935, Smithsonian Misc. Coll., vol. 93, no. 5, p. 24.
Dellea wilbernsensis WILSON, 1949, Jour. Paleontology, vol. 23, p. 35, pl. 11, figs. 1, 2, 4–7, 12.

Change in genotype nomenclature.—Wilson's original genotype, *Dellea wilbernsensis*, is considered probably conspecific with *Ptychoparia suada* Walcott 1890. This cranidium, a cast of which is figured, was placed in *Dunderbergia* by Resser in 1935 (p. 24) without comment. Comparison with the genotype, *Dunderbergia nitida*, has convinced the writer that these forms represent different stocks and are probably unrelated. Donald Duncan (personal communication) states that *D. nitida* is quite likely allied to *Aphelaspis* and in the Cordilleran sections is found below the typical development of the *Elvinia* fauna. The specimen which now becomes the type of the genotype of *Dellea* is a fragmentary cranidium lacking the border, palpebral lobes and posterior limbs. Four visits to Baldy Mountain section in Texas in search of topotype material indicate that such is rare. Four other cranidia have been found. Here *Dellea* is associated with the *Burnetia-Elvinia* assemblage and restricted to beds less than 19 feet below the *Irvingella* faunizone. Fortunately abundant specimens of this species are present from other sections in Texas and Pennsylvania.

Description.—The cranidium was rather completely described by the writer in 1949. The mean brim:border ratios in the topotype population and two from the Ore Hill are from 1.5 to 1.7. The glabella shows two or three pairs of faint furrows and is well elevated above horizontal or gently convex cheeks. The dorsal furrow is well defined

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EXPLANATION OF PLATE 93

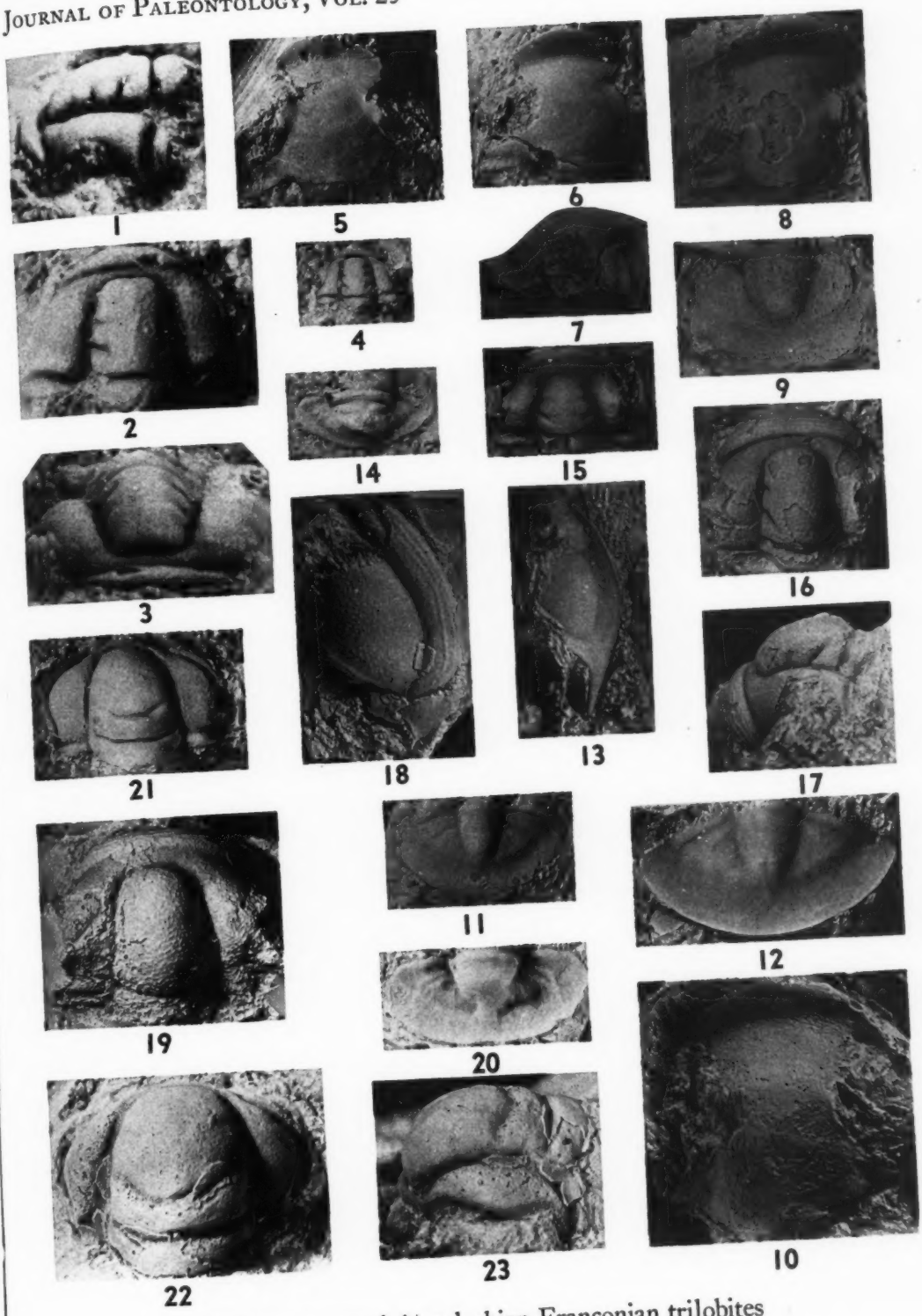
FIGS. *1–4, 15*—*Pinctus latus* Wilson, n. sp., *1–3*, profile, dorsal, and frontal views, ×15, of type cranidium, YPM 18527, 47-3w.26; *4*, dorsal view, ×6, of cranidium with unusually long glabella, YPM 18523, 47-3w.26; *15*, dorsal view, ×6, of large cranidium, YPM 18525, 47-5w.5. (p. 646)

5–13—*Housia vacuna* (Walcott), *5*, dorsal view, ×2, of cranidium, YPM 18426, 47-6w.5; *6, 7*, dorsal and profile views, ×4, of cranidium, YPM 18428, 47-3w.19; *8*, dorsal view, ×4, of cranidium, YPM 18427, 47-3w.19; *9*, dorsal view, ×2, of plaster cast of syntype pygidium, USNM 23862, Black Hills, South Dakota; *10*, dorsal view, ×2, of plaster cast of syntype cranidium, USNM 23862, Black Hills, South Dakota; *11*, dorsal view, ×2, of pygidium with anterior segment attached, YPM 18430, 47-6w.5; *12*, dorsal view, ×2, of pygidium which has shed anterior segment, YPM 18429, 47-6w.5; *13*, dorsal view, ×3, of free cheek, YPM 18424, 47-3w.14. (p. 643)

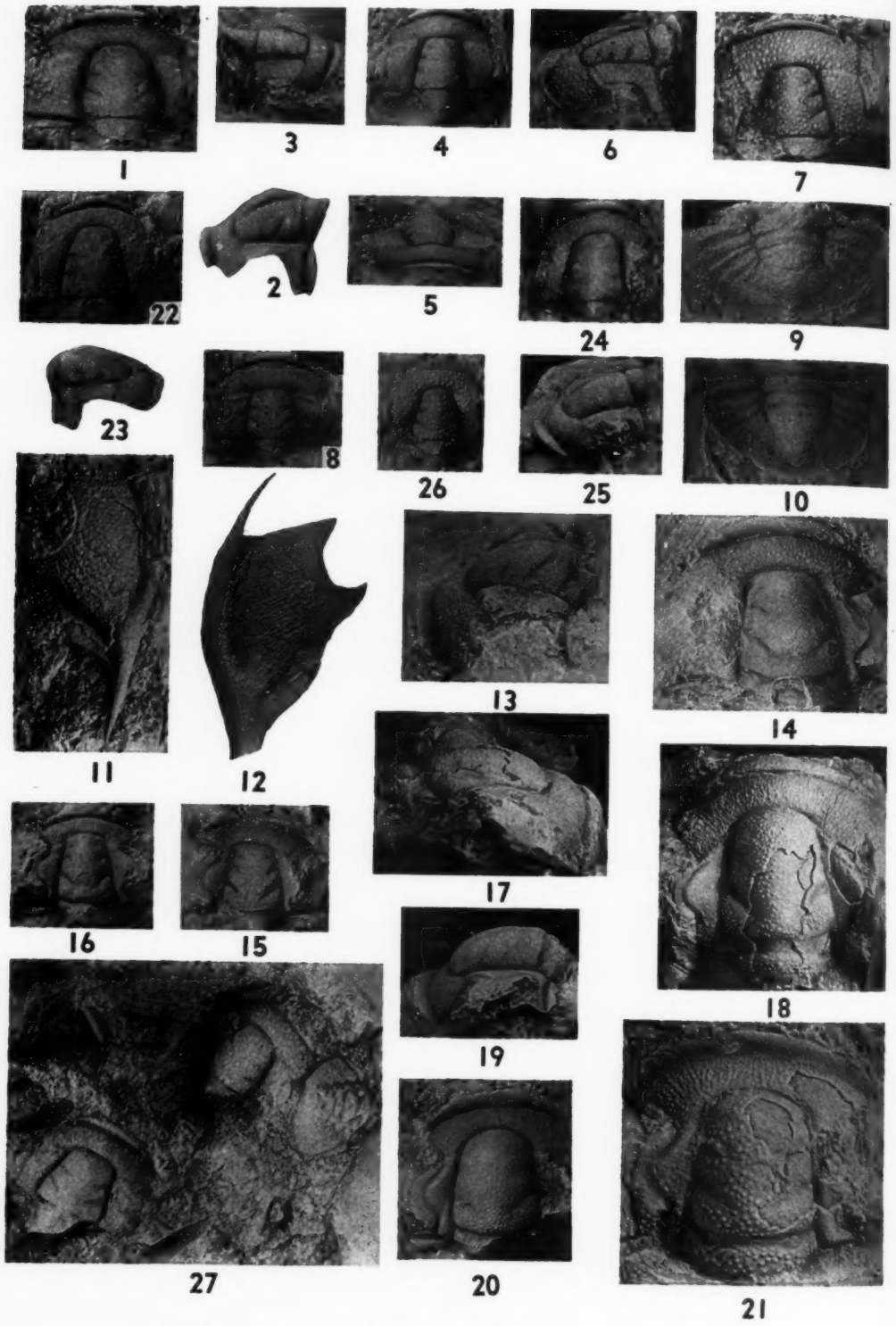
16–19—*Kyphocephalus ponderosus* Wilson, n. sp., *16, 17*, dorsal and profile views, ×3, of type cranidium, YPM 18484, 47-3w.19; *18*, dorsal view, ×2, free cheek, YPM 18602, 45-2w.5; *19*, dorsal view, ×2, of cranidium, YPM 18583, 45-2w.1. (p. 646)

20—Unassigned pygidium P, dorsal view, ×4, YPM 18562, 47-6w.5. (p. 650)

14, 21–23—*Irvingella major* Ulrich & Resser, *14*, dorsal view, ×3, of associated pygidium of type different from typical *Irvingella* pygidium, YPM 18521, 47-6w.5; *21*, dorsal view, ×6, of small cranidium, YPM 18522, 47-6w.5; *22, 23*, dorsal and profile views, ×4, of larger cranidium, YPM 18520, 47-3w.22. (p. 644)



Wilson, Central Appalachian Franconian trilobites



Wilson, Central Appalachian Franconian trilobites

but narrow; the brim non-convex but steeply deflexed. The radius of curvature of the marginal furrow is slightly less than the cranidial length, the mean of which is between 5 and 6 mm. The convergence of the anterior facial sutures is much greater than in *Berkeia typica*.

Free cheek much like that of *Deadwoodia duris* but with no change in declination on ocular platform which is evenly deflexed. Border horizontal, well-defined, and about a third width of ocular platform; anterior extension tapered to a point showing that facial suture is intramarginal to center; posteriorly border projected into a normal genal spine.

Pygidium semielliptical, almost 1.5 times wider than long, though some specimens show more circularity; lateral corners blunt and rounded. Axis occupying one-third width and slightly over half length of pygidium, very prominent owing to distinct dorsal furrow, possessing three rings and terminal segment excluding anterior half ring. On internal impressions three pleural segments visible with rather well-defined pleural grooves although on specimens with test preserved segmentation much fainter; pleural platform moderately convex, sloping down to a wide concave area which rises to a thin posterior border.

Discussion.—Considerable latitude is allowed in *D. suada* to include such forms from the Ore Hill member as "*Asaphiscus*"? cf. *florus* Walcott (see also specimen figured in this paper). These may represent a different species characterized by an upturned brim, strong ocular ridge, and more than ordinarily divergent anterior facial sutures. No well-defined population of this form is yet known and it is not given a specific name.

It has been the writer's observation when dealing with cranidia other than those of very small (juvenile) forms that proportions do not change appreciably with continuing growth. As an example of this it is noted that in cranidia of *Dellea suada* from 4 to 10 mm. long both the axial length and width of fixed cheek ratios show non-directional regression diagrams when plotted against length.

Examination of specimens within a population shows some slight change in furrows with increasing size. The glabellar furrows are more noticeable on larger specimens. The greater width of the dorsal furrow on large specimens increases a tendency toward a preglabellar platform on the brim. These forms also may have more convex fixed cheeks.

Occurrence.—*Dellea suada* is the most

EXPLANATION OF PLATE 94

FIGS. *1, 2*—*Drabia* sp. undet., dorsal and profile views, ×6, of cranidium, YPM 18590, 45-1w.3. (p. 641)

3–5, 8—*Drabia acroccipita* Wilson, n. sp., *3–5*, profile, dorsal, and frontal views, ×6, of type cranidium, YPM 18452, 47-5w.3; *8*, dorsal view, ×4, of cranidium, YPM 18451, 47-8w.6. (p. 640)

6, 7, 26—*Drabia menusa* Wilson, n. sp., *6, 7*, profile and dorsal views, ×6, of type cranidium, YPM 18462, 47-5w.8a; *26*, dorsal view, ×6, of small cranidium, YPM 18463, 45-2w.2. (p. 641)

9–16—*Pseudosaratogia magna* Wilson, n. sp., *9*, dorsal view, ×4, of pygidium, YPM 18440, 47-8w.1; *10*, dorsal view, ×6, of pygidium, YPM 18439, 47-16w.7; *11*, dorsal view, ×4, of free cheek, YPM 18445, 47-16w.7; *12*, dorsal view, ×4, of free cheek, YPM 18435, 45-1w.6; *13, 14*, profile and dorsal views, ×3, of cranidium, YPM 18437, 47-16w.7; *15*, dorsal view, ×3, of cranidium, CW-180, 47-8w.1; *16*, dorsal view, ×4, of small cranidium, the type, YPM 18444, 47-16w.7. (p. 648)

17, 18—*Pseudosaratogia bulbosa* Wilson, n. sp. profile and dorsal views, ×2, of type cranidium, YPM 18589, 47-3w.26. (p. 649)

19–21—*Pseudosaratogia lata* Wilson, *19, 20*, profile and dorsal views, ×3, of type cranidium, YPM 18598, 47-3w.19; *21*, dorsal view, ×4, of pustulose cranidium, YPM 18588(plaster cast), USNM collections, loc. 107v, Drab, 47-3w. (p. 648)

22–25, 27—*Drabia curtoccipita* Wilson, n. sp., *22, 23*, dorsal and profile views, ×6, of cranidium, YPM 18458, 47-23w.3; *24, 25*, dorsal and oblique-lateral views, ×6, of type cranidium, YPM 18592, 45-1w.3; *27*, dorsal views, ×6, of two cranidia and an associated pygidium possibly of this species, YPM 18459a and b, 45-1wa.2. (p. 641)

common trilobite in the *Elvinia* zone of the Ore Hill limestone. Several hundred cranidia are present in the collection, one bed alone yielding over 200 specimens: 45-2w.2; 47-3w.16, 3w.17, 3w.18?, 3w.20, 3w.26, 3w.28; 47-5w.3 (very common), 5w.5 (common), 5w.8a (very common); 47-2w.1 ?; 47-6w.5, 6w.6; 47-8w.2 ?, 8w.4, 8w.6; 47-15w.1, 15w.2, 15w.3; 47-20w.1 (very common).

Type.—U. S. Nat. Mus. 23860, fragmentary cranidium, Baldy Mountain, 42-9w, Burnet County, Texas. Other specimens: YPM 18415, cran., 47-5w.8a; YPM 18410, cran., 47-5w.3; YPM 18417, free cheek, 47-5w.8a; YPM 18412b, free cheek, 47-5w.3; YPM 18402, pyg., 47-20w.1; YPM 18412a, pyg., 47-5w.3; YPM 18413, pyg., 47-3w.26; YPM 18403, cran., 45-2w.4 [like "*Asaphiscus*"? cf. *florus* (Walcott)]; YPM 18418, cran., 47-3w.19 [like "*Asaphiscus*"? cf. *florus* (Walcott)].

DELLEA SARATOGOENSIS (Resser)
Plate 91, figures 12–17

Berkeia saratogoensis RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 91, pl. 15, figs. 22–25.

Berkeia glabellamersa WILSON, 1949, Jour. Paleontology, vol. 23, p. 36, pl. 11, figs. 13–15, (subspecies).

Supplementary description.—Cranidium quadrate excluding posterior limbs, considerably convex (due more to depression of brim, border, and posterior limbs than to elevation of glabella); considerable relief due to wide furrows. Glabella large, rounded, ratio of taper 1.4 (see table 3), more deeply furrowed than on other species, particularly on internal impressions; occipital ring commonly bears a slight node; dorsal furrow wide and deep. Brim slightly convex because of deep dorsal and marginal furrow; border widely arcuate, well defined, mean brim:border ratios for three small populations from 1.5 to 2.4. Mean axial length ratios for these about 3 or over. Fixed cheeks convex, on some specimens almost as high as glabella, mean width ratios on three populations 2.3 to 2.7; ocular ridge well defined; palpebral lobes moderately large and centered on glabella; posterior limbs deeply furrowed, extended straight out a distance equal to that across occipital ring.

Facial suture intramarginal to center, directed considerably inward between anterolateral corners and palpebral lobes behind which it indents before passing outward at 90° to longitudinal axis.

Comparisons.—The wide furrows and unelevated glabella of *Dellea saratogoensis* distinguish it from other species of the genus. In addition a small occipital node is generally present and the posterior limbs extend straight out instead of slightly backward as on *Dellea suada* and *Berkeia typica*. The chart of mean ratios (table 3) indicates that probably the fixed cheeks are not quite as wide as those of *Berkeia typica* but wider than on *Dellea suada* cranidia. The posteriorly converging anterior facial sutures form a laterally flared brim as on *Dellea suada*, differing in this from *Berkeia typica*. *D. saratogoensis* (Resser) resembles *Berkeia typica* Resser in the depth and wideness of the glabellar and dorsal furrows but is not considered a part of the *Berkeia-Sulcocephalus* lineage because of the difference cited above.

The species is known from many localities and shows some geographic variants. For example, comparison of the mean brim:border ratios in three small populations indicates close correlation of these ratios in *D. saratogensis* from the Conococheague limestone and the topotype material. Those specimens from the Ore Hill limestone, however, possess a comparatively larger brim at the axis, yet in all other features are closely similar to the topotype specimens. The Texas species, "*Berkeia glabellamersa*" Wilson 1949 is now considered a subspecies of *D. saratogoensis* (Resser). The two original specimens upon which this species was founded show its close relation to Resser's *Berkeia saratogoensis*. Now five other specimens are known from the lower Morgan Creek member of the Wilberns formation, Baldy Mountain, Texas (42-9w.12–14). These forms are essentially like *Dellea saratogoensis* (Resser) but much smaller (cranidial length consistently 3.5 to 4 mm.), have slightly wider fixed cheeks, and a brim:border ratio (1.7) more like that of the Ore Hill members of the species than the topotype material.

Occurrence.—Present though not as com-

mon as *Dellea suada* in the *Elvinia* zone of the Ore Hill member. Evidently a geographically widespread species; found in New York, Pennsylvania, Maryland, and Texas. Present with the *Pseudosaratogia magna* fauna in the Conococheague limestone, 45-2w.2, 47-3w.14, 3w.22; 47-5w.3, 5w.5 (common), 5w.8a (common); 47-6w.6, 6w.5 ?; 47-16w.7 (common), and 47-20w.1.

Type.—Specimens in New York State Museum; casts in U. S. Nat. Mus. 108792a.

elongate aspect; and in the bulbous very convex glabella."

On the Ore Hill specimens the glabella is quite prominent, without noticeable furrows, and more tapered than in *D. suada*. The radius of curvature of the border is shorter than in other species of the genus. There is some variation in the brim:border ratio. The posterior limbs are directed slightly backward, more so in this species than in any other in the genus.

TABLE 4.—COMPARISONS, *Dellea saratogoensis* AND SIMILAR SPECIES

Character	*Dellea saratogoensis*	*Dellea saratogoensis glabellamersa*	*Dellea suada*	*Berkeia typica*
Elevation of fixed cheeks	convex	convex	flat or slightly convex	down-sloping
Convexity of brim	moderate	moderate	none except as a possible gerontic feature	pronounced
Strength of dorsal furrow	deep and wide	deep and wide	well defined but not deep	deep and wide
Strength of glabellar furrows on internal impressions	deep	moderate	faint	deep
Elevation of glabella	slight	slight	considerable	considerable
Length of radius of curvature of marginal furrow	considerably more than two-thirds of axial length of cranidium			about two-thirds of axial length of cranidium.
Degree of convergence of anterior facial sutures	moderate	moderate	moderate to considerable	none

Other specimens: YPM 18406, cran., 47-5w.3; YPM 18434, cran., 47-5w.8a; YPM 18419, cran., 47-5w.5; YPM 18408, cran., 47-16w.7; CW-314, topotype cran., Greenfield, New York.

DELLEA BUTLERENSIS Frederickson
Plate 91, figures 1–3, 11

Dellea butlerensis FREDERICKSON, 1949, Jour. Paleontology, vol. 23, p. 351, pl. 69, figs. 16–18.

This species is not represented by enough good material to permit an adequate idea of intrapopulational variation. Frederickson states that it differs from his species *D. juvenalis* (close to *D. suada*) in possessing "narrower free [fixed?] cheeks and brim and border which gives the cranidium an

The writer considers the Texas specimen, *Dellea* sp. undet. (Wilson, 1949, pl. 11, fig. 10) to belong to *D. butlerensis*.

Occurrence.—Commonly found low in the *Elvinia* zone of the Ore Hill member, more generally in the *Pseudosaratogia magna-Elvinia* transition fauna of the Ore Hill. The species was not collected from the Conococheague limestone. It is seemingly of wide geographic distribution, being known from Texas and Oklahoma *Elvinia* zone beds as well as in Pennsylvania. In the Ore Hill present at 45-2w.2; 47-3w.6, 3w.5, 3w.19 (common), 3w.22 (common), 3w.26 (common); 47-6w.2; 47-8w.2, 8w.4; 47-15w.2.

Figured Specimens.—YPM 18422, cran., 47-15w.2; YPM 18421, cran., 47-3w.19.

Genus DOKIMOCEPHALUS Walcott 1924

DOKIMOCEPHALUS INTERMEDIUS
(Resser)
Plate 90, figure 25

Burnetia intermedia RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 80, pl. 17, figs. 10, 11.
Burnetia extensa RESSER, idem (pars), p. 81, pl. 17, figs. 15–20.
Burnetia lingula RESSER, idem, p. 82, pl. 17, figs. 32, 33.
Dokimocephalus intermedia (Resser), FREDERICKSON, 1948, Jour. Paleontology, vol. 22, p. 801, pl. 123, figs. 1–3.
Dokimocephalus intermedius (Resser), WILSON, 1949, Jour. Paleontology, vol. 23, pl. 9, figs. 1, 2, 4, 5.

Frederickson (1948, p. 802; see Resser, 1942, p. 17, fig. 19) notes a possible variant of *D. intermedius* in which the anterior facial sutures converge to form a bluntly pointed border. The writer assigns specimens of this nature from the Ore Hill member (and also some in the Wilberns limestone of Texas) to *Dokimocephalus intermedius* because he considers that the extremely variable course of the anterior facial suture in this genus makes it inadvisable to consider minor differences in its pattern as grounds for specific distinction.

Occurrence.—Very rare in the typical *Elvinia* fauna of the Ore Hill member; 47-5w.3, 5w.8a, and 47-6w.5.

Figured specimen.—YPM 18489, cran., 47-5w.8a.

Genus DRABIA Wilson, n. gen.

Cranidium small (2 to 5 mm. in basal width), slightly convex, subquadrate in outline excluding posterior limbs. Glabella rather prominent, ratio of taper about 1.5, truncate, well defined by a dorsal furrow deeper laterally than in front of glabella, unarched, in profile evenly declining toward front; three pairs of glabellar furrows, anterior one faint, last two well developed, all oblique; occipital ring well defined and unique in its backward projection, in some cases forming a thick blunt spine or cusp, in others merely bearing a node. Brim slightly deflexed at axis, laterally unflared but much more strongly deflexed, slightly convex; marginal furrow distinct; border convex, evenly tapered laterally and from half to one-third axial length of brim. Fixed cheeks of variable width (ratio about 2), varying from slightly down-sloping to gently convex; ocular ridge strong; palpebral lobes moderately large and centered on glabella; posterior limb rather narrow, deeply furrowed, deflexed and not far extended.

Free cheek unknown.

Facial suture intramarginal almost to center, proceeding straight back from anterolateral corner to palpebral lobe and behind this out at about a 60° angle to longitudinal axis.

Ornamentation commonly absent although specimens of *D. curtoccipita* from 47-23w.3 are granulose and all specimens of *D. menusa* are strikingly so.

Discussion.—This small genus is characterized by lack of cranidial convexity, wide fixed cheeks, an evenly declining though unarched glabella, deep lateral dorsal furrow, relatively narrow border, and backward pointing occipital lobe. It is stratigraphically important; its presence in both the Ore Hill and Conococheague limestones helps support their correlation. Numerous other small trilobites which may be assigned to this genus occur in both units, but less fragmentary and less distorted material is necessary before further study is done.

Genotype: *Drabia acroccipita* Wilson, n. sp.

DRABIA ACROCCIPITA Wilson, n. sp.
Plate 94, figures 3–5, 8

The genotype is represented by numerous well-preserved cranidia and is characterized by a rectangular, truncate glabella and a large posteriorly extended occipital ring. The distance from the end of the occipital ring to the occipital furrow may be about equal to the axial lengths of brim and border. This posterior extension of the occipital ring may not be homologous with an occipital spine; such arises axially from the dorsal surface of the ring, but the whole ring projects backward to a blunt point or cusp on *D. acroccipita*. The fixed cheeks are horizontal or downsloping and wide, their ratio on 15 specimens varying from 1.5 to 2.3. The brim:border ratio ranges from 2 to 3; the brim is convex, rising in some specimens to suggest a medial axial boss.

Occurrence.—Fairly common in the *Elvin-*

ia fauna of the Ore Hill member, unknown in Mid-continent *Elvinia* faunas; 45-2w.2? 47-3w.6, 3w.14, 3w.14a, 3w.26 (common), 3w.28 (common); 47-5w.3 (common), 5w.5, 5w.8a (common); 47-6w.6; 47-8w.6; and 47-15w.3.

Type.—YPM 18452, cran., 47-5w.3. Other specimens: YPM 18451, cran., 47-8w.6.

DRABIA MENUSA Wilson, n. sp.
Plate 94, figures 6, 7, 26

Cranidium small (about 4 mm. square), quadrate excluding posterior limbs, moderately convex. Glabella large, convex and sunken, tapered but truncate, its furrows well defined; dorsal and occipital furrows wide; occipital ring with a central node instead of backward pointing cusp. Brim highly convex about sunken anterior end of glabella; brim:border ratio about 3; border well defined, gradually and slightly tapered. Width of fixed cheeks ratio less than 2, generally about 1.5, the cheeks, after rising from dorsal furrow very gently downsloping in all directions; palpebral lobes rather long, thin, and extending from point lateral to anterior glabellar furrow to posteriormost pair; posterior limb poorly known, probably well-extended and strap-like.

Whole cranidium coarsely granulose except on border.

Remarks.—The ornamentation, narrow border, and steeply depressed brim are distinguishing traits of *D. menusa*, only six cranidia of which are known from three localities.

Occurrence.—Rare in the *Elvinia* fauna of the Ore Hill member; 45-2w.2; 47-5w.5, 5w.8a.

Ttype.—YPM 18462, cran., 47-5w.8a. Other specimens: YPM 18463, cran., 45-2w.2.

DRABIA CURTOCCIPITA Wilson, n. sp.
Plate 94, figures 22–25, 27

Glabella comparatively long, its axial length plus that of occipital ring occupying three-quarters that of cranidium. Occipital ring projects backward but usually not as much as in genotype; more commonly it bears a node. A short radius of curvature of marginal furrow gives cranidium an elongate appearance compared with other species; brim:border ratio as on genotype. Dorsal furrow rather shallow on some specimens. Horizontal fixed cheeks narrower than on other species, their width ratio varying from 2 to 2.5.

This species is the most important of several from the Conococheague limestone. Several localities furnished only badly distorted specimens and the accuracy of its description may suffer on this account.

Occurrence.—In *Pseudosaratogia magna* fauna of the Conococheague limestone and Ore Hill member; 45-1wa.2; 45-1w.3, 1w.4, 1w.6; 47-23w.3; 47-28w.2; 47-6w.1.

Type.—YPM 18592, cran., 45-1w.3. Other specimens: YPM 18458, cran., 47-23w.3; YPM 18459a and b, 2 cran. and pyg., 45-1wa.2.

DRABIA (?) sp. undet.
Plate 94, figures 1, 2

Numerous specimens of small fragmentary cranidia of the *Drabia* type possess less truncate and more anteriorly rounded glabellas and occur in two localities in the Conococheague limestone: 45-1w.3 and 47-23w.3. These are not yet well enough understood to warrant naming a new species.

Figured specimen.—YPM 18590, cran., 45-1w.3.

Genus ESHELMANIA Wilson, n. gen.

Cranidium small (less than 5 mm. long on all specimens available), convex, elongate excluding posterior limbs, and neatly but not deeply furrowed. Glabella quadrate, untapered, elevated and prominent, with occipital ring occupying 0.8 of cranidial length; always three pairs of oblique glabellar furrows; occipital ring and furrow normal. Brim steeply deflexed and continuing anterior declination of glabella without a change in angle; brim:border ratio 2 to 3; border neatly defined, laterally untapered, and horizontal. Fixed cheeks narrow, their width ratio about 4 excluding palpebral lobes, moderately convex, downsloping in all directions; palpebral lobes moderately large, centered on glabellar mid-point; ocular ridges well-defined; posterior limbs at base about equal to axial length of brim and border, strongly recurved, well-furrowed.

Free cheek unknown.

Facial suture cuts anterior margin well

out from center and trends inward somewhat before reaching palpebral lobe; posteriorly curving strongly outward.

Genotype: *Eshelmania snoburgensis* Wilson, n. sp.

Discussion.—This genus is comparable to *Dellea* in its similar proportions and depth of furrows. It differs fundamentally from *Dellea* in its long quadrate glabella with three pairs of furrows and in the recurvature of the posterior limbs. The genus is important stratigraphically, occurring in the *Pseudosaratogia magna* fauna of both the Ore Hill and Conococheague limestones.

ESHELMANIA SNOBURGENSIS Wilson, n. sp.
Plate 92, figures 9–15

Represented by about eight specimens several of which show strongly recurved posterior limbs as in the genus *Blountia*. The glabella is not so elevated as in *E. convexa*.

Occurrence.—In the *Pseudosaratogia magna* fauna at base of Ore Hill member, 47-8w.1 and 8w.3; and in the Conococheague limestone at 45-1w.2 and 45-1w.4.

Type.—YPM 18532a, cran., 47-8w.1. Other specimens: YPM 18487, cran., 47-8w.1; YPM 18486, cran. 47-8w.1; YPM 18532b, cran. with type, 47-8w.1; YPM 18485, deformed cran., 45-1w.3.

ESHELMANIA CONVEXA Wilson, n. sp.
Plate 92, figures 7, 8

Four cranidia from the *Pseudosaratogia magna* fauna of the Conococheague limestone at 47-16w.5 are close to the genotype but have an unusually long, very elevated glabella extending some distance anterior to the proximal end of the ocular ridge and shortening a steeply deflexed brim and border. The incomplete posterior limbs of the type are supplemented by other specimens which show a backward curvature as in the genotype.

Type.—YPM 18488, cran., 47-16w.5.

Genus ELVINIA Walcott 1924
ELVINIA ROEMERI (Shumard)
Plate 92, figures 18–22

Dikelocephalus roemeri SHUMARD, 1861, Amer. Jour. Sci., 2nd ser., vol. 32, pp. 220–221.
Elvinia roemeri (Shumard) WALCOTT, 1925, Smithsonian Misc. Coll., vol. 75, no. 3, p. 88, pl. 17, figs. 9–13.
Elvinia roemeri (Shumard) BRIDGE, 1937, U. S. Geol. Survey, Prof. Paper 186-M, pp. 251–255, (Complete synonymy to date, full discussion of species), pl. 69, figs. 1–21.
Elvinia roemeri (Shumard) WILSON, 1949, Jour. Paleontology, vol. 23, p. 38, pl. 10, figs. 5, 9, 10, 12, 13.
Elvinia roemeri (Shumard) FREDERICKSON, 1949, Jour. Paleontology, vol. 23, p. 352, pl. 69, figs. 19–21.

Bridge in 1937 published a careful analysis of the species *Elvinia roemeri* showing that its variations in cranidial proportions had no stratigraphic or geographic significance. This work was ignored without comment by Resser in 1942 when he completed his division of *Elvinia roemeri* into 16 species. The writer considers none of these valid. Resser neglected to consider forms of *Elvinia* known to him from the Ore Hill limestone. The writer concurs with Bridge (1937, p. 255) in assigning all specimens of *Elvinia* in the Ore Hill member to the species *E. roemeri*. Since Bridge's complete description and discussion of the genus this has become one of the best known Upper Cambrian trilobites.

The largest specimen of *Elvinia roemeri* collected from the Ore Hill member was a fragment whose cranidial length would have been 37 to 38 mm. indicating a total length for the trilobite of at least 15 cm. Several immature cranidia are figured in which relative proportions of the palpebral lobe and brim are different from those of full sized specimens.

Occurrence.—As in most other assemblages of this age, *Elvinia roemeri* is among the commonest as well as largest of the trilobites. In the Ore Hill member it was found only above the *Pseudosaratogia magna* faunule. 45-2w.1; 47-3w.14, 3w.15, 3w.18, 3w.19, 3w.20, 3w.22, 3w.26; 47-5w.3 (common), 5w.5 (common), 5w.8a (common); 47-6w.2, 6w.5, 6w.6; 47-8w.6.

Figured specimens.—YPM 18491, small cran., 47-5w.3; YPM 18492, very small cran., 47-5w.8a; YPM 18496, free cheek, 47-5w.8a; YPM 18493, cran., 47-5w.8a; YPM 18490, pyg., 47-5w.3.

Genus HOUSIA Walcott 1924

Supplementary description.—Cranidium long and narrow excluding posterior limbs, highly convex, only very slight relief to individual parts. Glabella almost indistinct

and flat, with occipital lobe occupying about two-thirds length of cranidium, anteriorly somewhat tapered and subquadrate; glabellar furrows faint to absent; occipital ring hardly distinguishable. Brim with anterior fourth of glabella abruptly and flatly deflexed on species preserved in limestone but undepressed at anterolateral corners; marginal furrow wide and shallow; border sharply upturned, flat, evenly tapered laterally, brim:border ratio between 1 and 2. Fixed cheek represented only by flap-like, semicircular palpebral lobes; posterior limbs long and narrow, steeply deflexed and more deeply furrowed than any other feature on cranidium.

Facial suture intramarginal to center, trending considerably inward anterior to palpebral lobe, almost intersecting the dorsal furrow at both ends of this feature; behind the lobe curving alongside of glabella and farther back trending outward along posterior limb at 45° angle to the axis.

For free cheek and thorax see original generic description.

Pygidium about twice as wide as long, its axis well defined and sharply tapered, convex, either faintly segmented or smooth and from half to two-thirds total axial length. Pleural platforms show one or two segments, the foremost one occasionally being in process of disarticulation and extending into a long backward drooping spine in some species. Border very wide and flat, set below and separated from pleural platform by a wide shallow furrow. Posterior margin evenly curved; anterior margin posterolaterally directed if the anterior segment has been recently shed.

Discussion.—The species described by Walcott are preserved in shale and flattened whereas those from the Black Hills and Pennsylvania are in limestone maintaining the original convexity. This fact accounts for certain minor inaccuracies and narrow specific concepts of the original description.

The family relations of this genus have been discussed by Whitehouse (1939, p. 245) who considered it synonymous with *Proceratopyge* from the *Lejopyge laevigata* zone of Sweden. The present writer, however, prefers to consider *Housia* as a valid genus more closely related to such early asaphids as *Bellefontia* and *Xenostegium* than to the Ceratopygidae Whitehouse laid most emphasis on the similarity of the *Housia* pygidia to those of *Proceratopyge*, neglecting the fact that the cranidia are dissimilar. These differ in brim:border relations, glabellar convexity, and definition of the dorsal furrow, the latter two characters being much less marked in *Housia*. The pygidia of *Housia* have a much less strongly segmented axis than those of *Proceratopyge*. In the writer's opinion generic synonymy is not yet demonstrated and the acceptance of such is possibly confusing to interprovince correlation. The suggested relationship of *Housia* to the asaphids is based on a morphological similarity much closer than between it and the *Ceratopygidae* but no connecting forms of Trempealeauian age between *Housia* and the Canadian trilobites are known.

HOUSIA VACUNA (Walcott)
Plate 93, figures 5–13

Ptychoparia vacuna Walcott, 1890, Proc. U. S. Nat. Mus., vol. 13, p. 275, pl. 21, figs. 8, 12.
Housia vacuna (Walcott) Resser, 1936, Smithsonian Misc. Coll., vol. 95, no. 4, p. 23.

Walcott failed to note the semicircular flap-like palpebral lobe of his specimens. His description also indicates incorrectly that the steep anterior deflection of the cranidium begins at the dorsal furrow; actually the anterior fourth of the glabella curves downward and the brim merely continues this slope. The upturned border tapers only slightly laterally. The wide free cheek has a normal genal spine and a border about half the width of the ocular platform.

Pygidium with a large tapered but bluntly pointed and faintly segmented axis (exfoliated specimens show four rings and a posterior segment); pleural platform with one or two furrows even when anterior segment unformed, deflexed steeply to border which is about one-third of pygidial axial length and flatly depressed with no raised rim along the posterior margin. The anterior segment has no long backward drooping spine as in *H. varro* and *H. canadensis* but a short one protruding only as far out as the margin. Of the 150 pygidia of *H. vacuna* from the Ore Hill limestone well enough preserved anteriorly to make the case clear, almost half showed the anterior segment in stages of disarticulation (either merely marked by a line of fracture across the pygidium or completely separated part way across with

the small posteriorly directed point well developed at the margin). Several pygidia showed two segments in a state of disarticulation; possibly pygidial segments of *Housia* are not as well joined as in other trilobites. Pygidia which have lost the segment may be identified by the sharply defined posterolaterally directed anterior margin.

Discussion.—The Ore Hill material does not differ appreciably from casts of the holotype. The cephalon of *Housia* is more delicately constructed than the pygidium. The long narrow posterior limbs and upturned border tend to snap off making the resulting fragments of the cranidium unidentifiable. The collections afforded only about 40 cranidia and over five times as many (219) pygidia. A negligible number of free cheeks was found. These were readily identified by the characteristic wide sweeping facial suture.

Occurrence.—A common but very sporadic member of the *Elvinia* fauna of the Ore Hill member; abundant when present but in places completely absent from the typical fauna; 47-3w.14 (very common), 3w.14a (common); 3w.15, 3w.16, 3w.22 (very common), 3w.26; 47-5w.5 (common); 47-6w.5 (very common), 6w.6; 45-2w.2.

Type.—U. S. Nat. Mus. 23862 (piece of rock bears two cranidia and a pygidium). Deadwood formation, limestone in Spring Creek Canyon, Black Hills, South Dakota.

Other specimens from the Ore Hill member, Pennsylvania: YPM 18426, cran., 47-6w.5; YPM 18428, cran., 47-3w.19; YPM 18427, cran., 47-3w.19; YPM 18424, free cheek, 47-3w.14; YPM 18430, pyg. with anterior segment, 47-6w.5; YPM 18429, pyg. without anterior segment, 47-6w.5.

Genus IRVINGELLA Walcott 1924

IRVINGELLA MAJOR Ulrich & Resser

Plate 93, figures 14, 21–23

Irvingella major ULRICH & RESSER in Walcott, 1924, Smithsonian Misc. Coll., vol. 75, no. 2, p. 58, pl. 10, fig. 3.

Irvingella major ULRICH & RESSER in Walcott, 1925, Smithsonian Misc. Coll., vol. 75, no. 3, p. 98, pl. 15, figs. 26–29.

Irvingella burnetensis Resser, WILSON, 1949, Jour. Paleontology, vol. 23, p. 39, pl. 11, figs. 18, 31.

Irvingella media Resser, WILSON, 1949, Jour. Paleontology, vol. 23, p. 39, pl. 10, fig. 7; pl. 11, figs. 16, 17, 19, 20.

Irvingella major Ulrich & Resser, FREDERICKSON, 1949, Jour. Paleontology, vol. 23, p. 353, pl. 69, figs. 5–7.

The Ore Hill has furnished about 100

EXPLANATION OF PLATE 95

FIGS. *1*—*Conaspis perseus* Hall, dorsal view, ×6, of fragmentary cranidium, YPM 18560, 47-20w.2. (p. 650)

2–5, 11—*Parabolinella occidentalis* Wilson, n. sp., *2*, dorsal view, ×6, of cranidium, YPM 18481, 47-10w.6; *3, 4*, dorsal and profile views, ×4, of type cranidium, YPM 18482, 47-5w.17; *5*, dorsal view, ×6, of clay cast of pygidium associated with this species, YPM 18480, 47–5w.17; *11*, dorsal view, ×4, of free cheek, YPM 18479, 47-5w.17. (p. 651)

6, 7—*Cheilocephalus* sp. undet., dorsal and profile views, ×2, of pygidium, YPM 18600, 45-2w.3. (p. 631)

8–10, 12—*Crepichilella antietamensis* Wilson, n. sp. *8*, dorsal view, ×4, of weathered cranidium, YPM 18595, 47-27w.3; *9, 10*, dorsal and profile views, ×4, of incomplete type cranidium, YPM 18596, 47-27w.3; *12*, dorsal view, ×4, of cranidium, YPM 18597. 47-27w.3. (p. 651)

13—unassigned pygidium B, dorsal view, ×6, YPM 18475, 47-3w.14. (p. 649)

14—unassigned pygidium L, dorsal view, ×4, of clay cast, YPM 18601, 47-5w.8a. (p. 650)

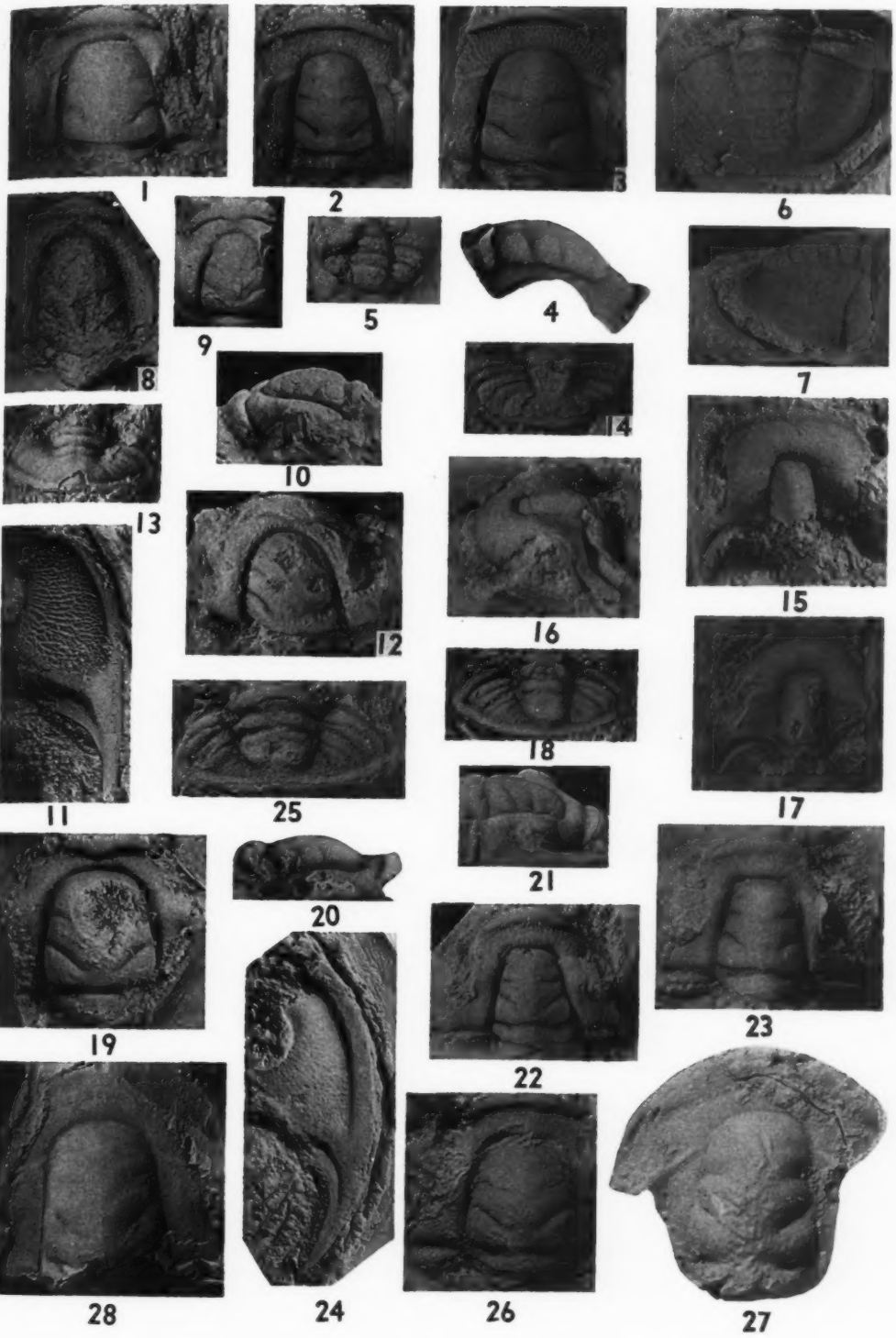
15–17—*Xenocheilos spineum* Wilson, n. sp., *15, 16*, profile and dorsal views, ×6, of type cranidium, YPM 18509, 47-3w.20; *17*, dorsal view of cranidium, ×6, YPM 18512, 47-6w.5. (p. 649)

18, 24, 26—*Taenicephalus* sp. undet., *18*, dorsal view, ×6, of pygidium, YPM 18576, 47-14w.1; *24*, dorsal view, ×4, of free cheek, YPM 18580, 47-14w.1; *26*, dorsal view, ×4, of cranidium, YPM 18573, 47–14w.1. (p. 653)

19, 20—*Conaspis ? retractalabra* Wilson, n. sp., dorsal and profile views, ×6, of type cranidium, YPM 18594, 47-5w.36. (p. 650)

21–23, 25—*Taenicephalus shumardi* (Hall), *21, 22*, profile and dorsal views, ×3, of best preserved cranidium, YPM 18577, 47-20w.5; *23*, dorsal view, ×6, of cranidium, YPM 18579, 47-20w.6; *25*, dorsal view, ×4, of pygidium, YPM 18574; 47-20w.6. (p. 652)

27, 28—*Wilbernia* sp. undet., *27*, dorsal view, ×3, of cranidium, YPM 18587, 47-8w.7; *28*, dorsal view, ×2, of large cranidium, YPM 18432, 47-5w.17. (p. 653)



Wilson, Central Appalachian Franconian trilobites

cranidia and a few pygidia all assigned to *Irvingella major*. Consideration of Resser's species of *Irvingella* (1942, pp. 13–25) was useless because he merely described specimens making no attempt to formulate a reasonable species concept (Frederickson, 1949, p. 353). The only consistent variation noted in the specimens was a difference in the convexity and degree of deflection of the fixed cheeks such as is indicated by Fredrickson although no grouping of the material on this basis is possible as with the Oklahoma specimens. Rather the larger individuals (cranidia above 8 mm. long) show flatter fixed cheeks and deeper dorsal and palpebral furrows, the glabellar convexity remaining about the same. Possibly the flattening indicates gerontism but it might also result from pre-burial depression of the larger cranidia. Hence all cranidia are referred to the genotype. Two of Resser's Texas species, *I. burnetensis* and *I. media*, were recognized and described by the writer in 1949. Though studies of population variation have yet to be made on members of this genus, it is the writer's opinion that these also fall within the limits of *Irvingella major* as demonstrated by the Oklahoma and Pennsylvania material since examined.

Associated with the *Irvingella major* cranidia in the Ore Hill are a few pygidia differing considerably in detail from those assigned to *Irvingella media* by the writer in 1949. Pygidia 2 to 2.2 times as wide as long (width of Texas specimens 1.6 to 1.7 times length); large elevated axis with two prominent rings and posterior segment as in Texas material, extending 0.8 of length and occupying over a third of width. Pleural platform commonly depressed and but faintly segmented; border narrow, rising at rounded anterolateral corners and again just behind axis to give characteristic undulating appearance in posterior view.

Occurrence.—Present throughout the range of the *Elvinia* fauna in the Ore Hill member but not present in the coquina above that fauna as in the Mid-continent area: 47-3w.6, 3w.16–3w.20, 3w.22 (common), 3w.26, 3w.28, 47-5w.5; 47-6w.5 (common); 47-8w.4, 8w.6; 47-20w.1 (common).

Figured specimens.—YPM 18521, pyg., 47-6w.5; YPM 18522, cran., 47-6w.5; YPM 18520, cran., 47-3w.22.

Genus KINDBLADIA Frederickson 1948
KINDBLADIA WICHITAENSIS (Resser)
Plate 92, figures 23, 24

Asaphiscus ? florus WALCOTT, 1916, Smithsonian Misc. Coll., vol. 64, no. 5, p. 392 (pars), pl. 63, fig. 6b, pygidium (non figs. 6, 6′, and 6a).
Berkeia wichitaensis RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 92, pl. 15, figs. 31–33.
Berkeia jucunda RESSER, idem, p. 93, pl. 16, figs. 5–10.
Berkeia missouriensis RESSER, idem, p. 94, pl. 16, figs. 11–14.
Kindbladia wichitaensis (Resser), FREDERICKSON, 1948, Jour. Paleontology, vol. 22, p. 802, pl. 123, figs. 20–23.
Kindbladia wichitaensis (Resser), WILSON, 1949, Jour. Paleontology, vol. 23, p. 40, pl. 9, figs. 14–18.

Occurrence.—Numerous cranidia of this species occur with the *Elvinia* fauna in the Drab section; 47-3w.17–3w.20, 3w.26. The same section (U. S. Nat. Mus. loc. 107v) furnished a pygidium figured by Walcott (1916, pl. 63, figs. 6b) and considered by him to belong to forms now assigned to *Dellea*. This type of pygidium has been discovered by Frederickson associated with the *Kindbladia* cranidium in Oklahoma.

Figured specimens.—USNM 62816. pyg., Loc. 107v, (45-2w); YPM 18529, cran., 47-3w.20.

Genus KYPHOCEPHALUS Miller 1936

The original description of the genus points out such distinctive characteristics as the deeply furrowed glabella, broad free cheek, coarsely granulated surface, flaring brim-border, and narrow marginal furrow. The addition of a second species and its comparison with Miller's types make possible a more complete generic concept.

Supplementary description.—Cranidium of moderate size (largest specimen 15 mm. long), highly convex with much relief to individual parts, squarish in outline. Glabella large, with occipital ring occupying about 0.75 of axial length of cranidium, well arched and prominent, degree of tapering variable, anterior corners well rounded; glabellar furrows varying in depth but generally well impressed and oblique; dorsal furrow quite deep; occipital ring and furrow normal. Brim widely flared and anterolaterally deflexed, separated from border by a marginal furrow varying from wide

to very narrow; border very thick, convex, brim:border ratio about 0.65. Fixed cheeks upsloping, their width ratio a little over 2; palpebral lobes of medium size, medially located approximately lateral to distal end of posterior glabellar furrow; ocular ridge of varying distinctness; posterior limbs sharply triangular, deeply furrowed and not greatly extended.

Free cheek quite wide; ocular platform outwardly convex, increasingly steeply deflexed from eye, border wide, genal spine probably blunt.

Facial suture cuts anterior margin about halfway to center, trends considerably inward behind anterolateral corners; behind palpebral lobes proceeds along posterior limbs but a short distance before cutting posterior margin.

All parts of cephalon granulose; Bertillon marks common on border.

Kyphocephalus is associated with better known genera of the *Elvinia* fauna in both Wyoming and Pennsylvania.

Genotype: *Kyphocephalus bridgerensis* Miller.

KYPHOCEPHALUS PONDEROSUS Wilson, n. sp.
Plate 93, figures 16–19

This species may be somewhat larger than the genotype, differing from it in its wide and deep marginal furrow, more highly arched glabella, weaker ocular ridge, and slightly posterior palpebral lobes. Pygidium unknown.

Occurrence.—A rare member of the *Elvinia* fauna of the Ore Hill member; 47-3w.6, 3w.19, 3w.22, 3w.26; 45-2w.1, 2w.2, 2w.5; 47-5w.5.

Type.—YPM 18484, cran., 47-3w.19. Other specimens: YPM 18583, cran., 45-2w.1; YPM 18602, free cheek, 45-2w.5.

Genus PINCTUS Wilson, n. gen.

Cranidium small and bluntly triangular in shape, moderately convex with well developed furrows. Glabella very long, prominent, convex, and quadrate with three pairs of well-impressed oblique furrows; occipital ring posteriorly extended at axis. Brim reduced and depressed; border prominent, widely arcuate, and considerably tapered; brim:border ratio about 1 or less. Fixed cheeks downsloping, moderately wide (ratio 2 or less); palpebral lobes small and thin, slightly anterior; posterior limbs broad and extended.

Facial suture intramarginal almost to axis, beginning to diverge already just behind anterolateral corner, indenting but slightly at each end of palpebral lobe, and sweeping outward behind it enough to give cranidium a wide base.

Discussion.—This form resembles immature specimens of *Berkeia granulosa* differing from them in having anteriorly instead of posteriorly placed palpebral lobes, a quadrate and untapered glabella, and a concave instead of convex brim.

Genotype: *Pinctus latus* Wilson, n. sp.

PINCTUS LATUS Wilson, n. sp.
Plate 93, figures 1–4, 15

Small forms, 2 to 2.5 mm. long, which are characterized by well-developed dorsal and glabellar furrows and a large slightly tapered quadrate glabella occupying with occipital lobe 0.75 of axial length of cranidium. Brim about size of border at axis; small palpebral lobes opposite or slightly anterior to middle glabellar furrow; broad posterior limbs extended laterally not quite as far as width of occipital ring and exceptionally deeply and broadly furrowed. Cranidia finely granulose.

A cranidium is illustrated which is closest to this species but differs from it in its untapered glabella which with occipital lobe occupies almost 0.9 of axial length of cranidium completely replacing brim at axis and extending to the marginal furrow.

Occurrence.—Rare, with the *Elvinia* fauna of the Ore Hill member; 47-3w.6, 3w.26, 3w.28, 3w.29; 47-5w.5; and 47-20w.1.

Type.—YPM 18527, cran., 47-3w.26; YPM 18523, cran., 47-3w.26; YPM 18525, cran., 47-5w.5.

Genus PLATASPELLA Wilson 1949

The genus *Plataspella* was erected for species of *Iddingsia* (Resser, 1942, pp. 87–90) which differ considerably from the genotype, *I. similis*, and from *I. robusta* and *I. nevadaensis* in having (1) a wide and shallow marginal furrow often separated from both brim and border by faint subsidiary grooves, (2) a flattened, laterally expanded brim and border, (3) fainter glabellar furrows, (4) a

long spine on the occipital ring, and (5) less elevated fixed cheeks. Other features of the cranidium are very similar in the two genera.

Iddingsia and *Plataspella* appear to intergrade in some localities despite the very different character of the end members. In the *Elvinia* fauna of Minnesota (V. E. Kurtz, personal communication) cranidia with glabellas and fixed cheeks of *Plataspella* type possess equal sized brims and borders, the latter being convex as in *Iddingsia*. Further, forms of *Plataspella* are known in Minnesota with glabellas as deeply furrowed as in *Iddingsia*. In the Davis formation of Missouri this situation obtains also in *Plataspella crassimarginata* (Resser). *Iddingsia missouriensis* (the writer is grateful to Dr. Franco Rasetti for loan of topotype material of the species) also shows some *Plataspella* characteristics. Other pairs of Upper Cambrian trilobite genera as presently conceived apparently intergrade, e.g. *Burnetia-Dokimocephalus*, *Conaspis-Taenicephalus*, and *Coosella-Crepicephalus*, the pair in each case belonging to the same fauna.

At present the genus *Plataspella* includes only three species:

1. *Plataspella anatina* (*Iddingsia anatina*, *I. alpersensis*, and *I. simplicitas* of Resser), the genotype, from Oklahoma, Texas, and Pennsylvania.
2. *Plataspella bicincta* (*I. bicincta* Resser), not yet restudied, from Oklahoma.
3. *Plataspella crassimarginata* (*I. crassimarginata* Resser), from Missouri and Minnesota.

PLATASPELLA ANATINA (Resser)
Plate 92, figure 6

Iddingsia anatina RESSER, 1942, Smithsonian Misc. Coll., vol. 103, no. 5, p. 80, pl. 17, figs. 1, 2.

Plataspella anatina (Resser), WILSON, 1949, Jour. Paleontology, vol. 23, p. 42, pl. 9, figs. 20–22, 25, 26.

Plataspella anatina (Resser), FREDERICKSON, 1949, Jour. Paleontology, vol. 23, p. 255, pl. 68, figs. 10–13.

No significant difference was observed in the material from the Ore Hill member and the type specimens from Oklahoma. The occipital spine is present in all the Ore Hill material well enough preserved to show the occipital ring.

Occurrence.—Present but uncommon in the Ore Hill member, all specimens from the Drab section; 47-3w.19, 3w.22, 3w.26 and U. S. Nat. Mus. loc. 107v.

Figured specimen.—YPM 18533, cran., 47-3w.22.

Genus PTEROCEPHALIA Roemer 1849
PTEROCEPHALIA SANCTISABAE Roemer
Plate 91, figure 24

Pterocephalia sanctisabae ROEMER, 1849, Texas, p. 421.

Pterocephalia sanctisabae Roemer, BRIDGE, 1937, U. S. Geol. Survey Prof. Paper 186-M, pp. 246–250 (complete synonymy to date, translation of original description, discussion of species and genus) pl. 67, figs. 1a–d, pl. 68, figs. 7–43. Because of the above careful analysis the writer does not follow Resser (1938, pp. 39–41) in dividing the species.

Pterocephalia sanctisabae Roemer, WILSON, 1949, Jour. Paleontology, vol. 23, p. 255, pl. 69, figs. 1–4.

Occurrence.—Of the several thousand trilobite parts collected from the Ore Hill member only three fragmentary cranidia of *Pterocephalia sanctisabae* were discovered, these with the *Elvinia* fauna: 47-5w.8a and 45-2w.2.

Figured specimen.—YPM 18559, fragmentary cran., 47-5w.8a.

Genus PSEUDOSARATOGIA Wilson, n. gen.

Cranidium large (largest 2.5 cm. long, average length 1 cm.), elongate excluding posterior limbs, moderately convex with considerable relief to individual parts. Glabella long, with occipital ring occupying about 0.75 axial length of cranidium, ratio of taper about 1.5, generally truncate, moderately convex; three pairs of well-incised glabellar furrows, their highly characteristic pattern varying specifically; occipital furrow and ring normal, the latter in some specimens bearing a weak node; dorsal furrow prominent. Brim well defined, steeply deflexed, rather flared anterolaterally, brim:border ratio varying specifically from 1.5 to 4; border well defined by wide and deep marginal furrow, slightly tapered laterally and either horizontal or turned slightly upward. Fixed cheeks reduced to laterally extended triangular flaps, exceedingly narrow anterior to palpebral lobe, their width ratio slightly over 2 at widest point, varying

from steeply upsloping to horizontal; ocular ridge strong; palpebral lobes unusually large, almost 0.5 width of fixed cheek at its midline in some species, centered on glabella and extended length of posterior two-thirds of this feature, widely crescentic; posterior limb quite narrow and straplike, extended straight out and slightly deflexed.

Free cheek with ocular platform curving steeply downward in wide arc from eye; marginal furrow easily visible; border rather narrow, well defined, rapidly tapering anteriorly on dorsal surface, widened in genal angle and projected in a spine; extension of posterior limb furrow well developed out into genal angle.

Facial suture intramarginal possibly halfway to center, indenting strongly both immediately anterior and posterior to palpebral lobe behind which it proceeds outward at right angles to longitudinal axis.

Pustules of all sizes completely cover cephalon in all species, weakest on border; irregular and anastomosing lines of pustules present on brim and ocular platform.

Pygidium assigned because of ornamentation, size, and common occurrence in coquinas of *Pseudosaratogia;* width about twice length, axis large, occupying almost 0.35 of width, elevated above pleural platforms, possessing three rings and a posterior segment; pleural platforms only moderately deflexed with three segments consistently visible and traces of a fourth; border very narrow, most pronounced along anterior margin which trends almost straight out from axis making sharp anterior corners about lateral to middle axial ring; posterior margin very widely arcuate with a weak border; pustulose like cranidium.

Comparisons.—The name *Pseudosaratogia*, suggested by Ulrich in an early identification of some Ore Hill trilobites, implies a resemblance to *Saratogia*, a late Trempealeauian genus from the Hoyt limestone. The genera have similarly shaped glabellas, the same type of glabellar furrows, unusually large palpebral lobes and exactly similar ornamentation. The pygidia are alike. *Pseudosaratogia* differs from *Saratogia* in its laterally flared brim. In the latter genus the anterior facial sutures converge only slightly but indent sharply anterior to the palpebral lobe, almost eliminating the fixed cheek there. The latter genus is also less convex and its occipital ring bears a long spine unknown in *Pseudosaratogia*.

Genotype: *Pseudosaratogia magna*, n. sp.

PSEUDOSARATOGIA MAGNA Wilson, n. sp.
Plate 94, figures 9–16

In this, the commonest species of the genus, the glabella arches downward in profile view and is noticeably truncate though its anterior corners are well rounded. The glabellar furrows are distinctive: the faint anterior pair straight, the two posterior pairs definitely sigmoid, and the last pair commonly joined across the glabellar axis. The dorsal furrow is deeper just opposite the anterior glabellar furrow. The brim is only slightly convex but steeply deflexed and the brim:border ratio from over 2 to about 4.

Occurrence.—Common in the Conococheague limestone from 50 to 500 feet above the lower sandy member, in different sections averaging about 300 feet above same, and ranging through over 100 feet of beds to whose fauna its name is given. The species commonly occurs with the genus *Buttsia*. Found also in the lower 15 feet of the Ore Hill member but never higher, nor in association with the typical *Elvinia* fauna. Ore Hill stations: 47-3w.6, 47-6w.1, 47-8w.1 (very common), 8w.1a, 8w.3; 47-15w.1. Conococheague limestone stations: 45-1w.2, 1w.2a, 1w.3 (common), 1w.4, 1w.5 (very common), 1w.6; 47-16w.7 (very common); 47-23w.3; 47-27w.2; 47-28w.2 (very common).

Type.—YPM 18444, cran., 47-16w.7. Other specimens: YPM 18439, pyg., 47-16w.7; YPM 18440, pyg., 47-8w.1; YPM 18437, cran., 47-16w.7; CW-180, cran , 47-8w.1; YPM 18445, free cheek, 47-16w.7; YPM 18435, free cheek, 45-1w.6.

PSEUDOSARATOGIA LATA Wilson, n. sp.
Plate 94, figures 19–21

This species differs most from the genotype. The glabella lies in a horizontal plane and is not anteriorly depressed. It is also rounded instead of truncate and the posterior two pairs of glabellar furrows are not sigmoid but straight and oblique. The brim lacks convexity and is steeply deflexed, the brim:border ratio being about 1.5 as compared with 3 or 4 in the genotype. The fixed

cheeks are horizontal instead of upsloping. Despite its aberrant character the course of the facial suture, large palpebral lobes, and characteristic ornamentaion place the form in *Pseudosaratogia*.

Occurrence.—One of two species of the genus occuring with the typical *Elvinia* fauna in the Ore Hill above the limited range of *P. magna*. A single specimen was found at 47-3w.19 at Drab. The National Museum collections, Washington, D. C., contain a tray of specimens of this species from the same section.

Type.—YPM 18598, cran., 47-3w.19. Other specimens: USNM Coll., unnumbered cran., loc. 107v; 47-3w, (YPM 18588, plaster cast).

PSEUDOSARATOGIA BULBOSA Wilson, n. sp.
Plate 94, figures 17, 18

The species differs from the genotype in having a much shorter brim, the brim:border ratio being about 2 instead of the usual 3 or 4. More important, the brim is not so steeply deflexed from the dorsal furrow and is bulbous in the preglabella area. The palpebral lobes are smaller than on the genotype and the facial suture does not indent anterior to them.

Occurrence.—From horizons in the middle Ore Hill member above the range of *P. magna* and associated with the typical *Elvinia* fauna. 47-3w.26, 3w.28, 3w.29; 47-20w.1, 20w.3.

Type.—YPM 18589, cran., 47-3w.26.

Genus XENOCHEILOS Wilson 1949
XENOCHEILOS SPINEUM Wilson, n. sp.
Plate 95, figures 15–17

Small species agreeing closely in size and structure to genotype, *X. minutum* Wilson 1949. Cranidium square excluding posterior limbs; glabella cylindrical and untapered but well rounded at front node. Anterior dorsal furrow very wide, giving glabella a sunken appearance as in genotype; posterior dorsal furrow shallower. Brim and border differ from those in *X. minutum*. Brim not steeply depressed as in genotype but evenly downsloping from dorsal furrow without forming a wide pre-glabellar platform. Border defined by a shallow marginal furrow—in some specimens merely noticeable in that a change of slope occurs with it. On numerous specimens border slightly but abruptly expands at center forming a backward pointed cusp into marginal furrow. Fixed cheeks slightly wider than glabella, commonly flat but slightly rising laterally to medium-sized semicircular palpebral lobes centered on glabella. Ocular ridges strong. Posterior limb differs from that of genotype in being longer and furrowed much nearer to its extremity (see lateral views of cranidia); it curves quite far backward and ventrad.

Course of facial suture like that of genotype although the spine-like posterior limb of *X. spineum* furthers the impression that this form is technically proparian. Discovery of the free cheek of this form in the Davis formation of Missouri shows that it possesses a long genal spine paralleling and lateral to that of the cranidium (V. E. Kurtz, The University of Oklahoma, personal communication).

Pygidium unknown.

Occurrence.—Present with the typical *Elvinia* fauna of the Ore Hill member; 47-3w.19, 3w.20, 3w.26; 47-6w.5 (common); 47-8w.4.

Type.—YPM 18509 cran., 47-3w.20. Other specimen: YPM 18512, cran., 47-6w.5.

Unassigned pygidium B
Plate 95, figure 13

Small, very wide and unusually narrow, highly convex. Blunt axis about 0.2 width and 0.5 length of pygidium, elevated anteriorly but posterior end almost merging with axial part of pleural platform, two sharply defined axial rings. Pleural platforms horizontal close to axis, distally deflexed almost vertically to well defined, thickened border which begins at sharp lateral corners. Anterior margin extends straight out but distally curves evenly back to lateral corners; posterior margin slightly elevated axially and widely arched.

Occurrence.—From association and comparable size perhaps belonging to cranidia of *Drabia* but quantity of material insufficient for proof. Found with the *Elvinia* fauna of the Ore Hill member and at one station in the Conococheague limestone with the *Pseudosaratogia magna* fauna. 47-3w.14, 3w.15, 3w.26; 47-5w.8a; 47-8w.6?; 47-16w.7.

Type.—YPM 18475, pyg., 47-3w.14.

Unassigned pygidium L
Plate 95, figure 14

About 1.5 times as wide as long, moderate in size, rounded in outline, and well furrowed. Axis occupies 0.25 of width and 0.35 of length of pygidium, only moderately elevated, marked by three rings; dorsal furrow deep. Pleural lobes moderately convex, possessing two prominent well-furrowed segments and traces of a third. Rows of pustules present along segments and some indication of a row of fine pustules in a shallow groove paralleling posterior margin and separating it from pleural platform. Border lacking, curving segments extending completely to posterior margin.

Occurrence.—Only two specimens known from a single locality, with *Elvinia* fauna of Ore Hill member; 47-5w.8a.

Type.—YPM 18601, pyg., 47-5w.8a.

Unassigned pygidium P
Plate 93, figure 20

Over twice as wide as long, with rounded extremities instead of lateral corners. Axis extremely elevated above pleural platforms, with two faintly marked segments, occupying 0.25 of pygidial width and about 0.5 its length. Pleural platforms poorly defined, flat or slightly concave, faintly marked with one segment showing single pleural furrow; a prominent ridge extends from posterior end of axis to posterior margin of pygidium; border lacking.

Occurrence.—With the *Elvinia* fauna in the Ore Hill member; 47-3w (U. S. Nat. Mus. no. 107v) and 47-6w.5.

Type.—YPM 18562, pyg., 47-6w.5.

MIDDLE FRANCONIAN TRILOBITES

Genus CONASPIS Hall

CONASPIS PERSEUS Hall
Plate 95, figure 1

Conocephalites perseus HALL, 1863, 16th Ann. Rept. New York State Cab. Nat. Hist., p. 153, pl. 7, figs. 17–33, pl. 8, fig. 33.
Conaspis perseus HALL, 1863, 16th Ann. Rept. New York State Cab. Nat. Hist., p. 152.
Conaspis perseus Hall, WALCOTT, 1914, Smithsonian Misc. Coll. vol. 57, no. 13, p. 357 (footnote).
Conaspis perseus Hall, RESSER, 1937, Smithsonian Misc. Coll., vol. 95, no. 22, p. 7.

The Ore Hill specimen is close to Hall's plate 7, figure 17. (W. C. Bell furnished the writer a stereoscopic pair of photographs of this syntype.) Hall's specific description is adequate. This form lacks the tumid glabella and horizontal groove joining the posterior pair of glabellar furrows possessed by certain specimens from the Croixan region to which this name has also been applied.

Occurrence.—A single specimen, 47-20w.2, from the upper Ore Hill member.

Figured Specimen.—YPM 18560, cran., 47-20w.2.

CONASPIS ? RETRACTALABRA Wilson, n. sp.
Plate 95, figures 19, 20

Cranidium quadrate, slightly convex, considerable relief to individual parts. Glabella large and quadrate, moderately elevated, rounded at front, with occipital ring occupying 0.75 to 0.85 of axial length of cranidium; two pairs of well-defined oblique glabellar furrows; occipital furrow well defined and occipital ring directed slightly backward as in *Conaspis perseus;* dorsal furrow very wide and deep. Brim reduced to a slightly convex swell between deep dorsal and marginal furrows, quite small anterior to glabella but expanding laterally; border prominent, elevated, and triangular because of rapid lateral tapering, posteriorly expanded at center, brim:border ratio about 1. Fixed cheeks horizontal, small palpebral lobes opposite middle glabellar furrow and anterior to center of glabella; posterior limbs unknown.

Facial suture intramarginal to center, proceeding almost straight back to palpebral lobes; posterior course unknown.

Comparisons.—*C. ? retractalabra* resembles *Bemaspis gouldi* Frederickson but differs from it in the central posterior expansion of the border, deeper dorsal furrow, more strongly arched fixed cheeks, and unkeeled, rather rounded and more tumid glabella. Until results of phylogenetic studies on conaspid trilobites from the Croixan region are published no very accurate idea of the genus *Conaspis* is possible. Therefore the generic assignment of *C. ? retractalabra* may be considered provisional. The species differs from *Conaspis perseus*, the genotype, in its deeper dorsal furrow, not quite so tumid glabella, and the axial posterior swelling of the border.

Occurrence.—Cranidia are known from the upper Ore Hill member with *Taenicephalus shumardi:* 47-5w.34, 5w.36, and 47-6w.3 (common).

Type.—YPM 18594, cran., 47-5w.36.

Genus CREPICHILELLA Wilson, n. gen.

Cranidium quadrate with great relief to individual parts. Glabella convex, well tapered, with occipital ring occupying about 0.75 total length of cranidium: three pairs of glabellar furrows, first faint, last two deeper and curved obliquely backward. Dorsal and occipital furrows very wide and deep; occipital ring normal or slightly directed backward at center. Brim convex, the ratio with border about 1; triangular border set off by deep marginal furrow. Fixed cheeks typically very convex and narrow, their width ratio about 3; palpebral lobes rather small, located just posterior to glabellar midpoint; posterior limbs comparatively narrow at base, extended straight out and deeply furrowed.

Facial suture intramarginal to center, extending almost straight back to palpebral lobe and without appreciable indentation at either end of lobe extending straight out behind it.

Free cheek and pygidium unknown.

Genotype: *Crepichilella antietamensis* Wilson, n. sp.

Comparisons.—This genus is similar to *Berkeia* and *Sulcocephalus* in the convex, tapered, well-furrowed glabella. It differs from these in the very convex and narrower fixed cheeks. The form probably occurs in middle Franconian strata.

CREPICHILELLA ANTIETAMENSIS Wilson, n. sp.
Plate 95, figures 8–10, 12

The species is based upon slightly distorted material. Since only a single species is known, some features considered generic may be of only specific importance. The distinguishing characteristic postulated for this species is the axially narrow and depressed brim which on large specimens appears to be cut away completely by the backward expansion of the border. The border is greatly thickened centrally.

Occurrence.—Conococheague limestone about 550 feet above the top of the lower sandy member and 35 feet above the highest occurrence of *Pseudosaratogia magna* with *Stigmacephalus* ?; 47-27w.3.

Type.—YPM 18596, cran., 47-27w.3. Other specimens: YPM 18595, cran., 47-27w.3; YPM 18597, cran., 47-27w.3.

Genus PARABOLINELLA Brogger 1882
PARABOLINELLA OCCIDENTALIS Wilson, n. sp.
Plate 95, figures 2–5, 11

Cranidium moderately convex with well-defined individual parts, rectangular excluding posterior limbs. Glabella long, well defined, somewhat truncate though with rounded corners, with occipital lobe occupying from 0.75 to 0.8 length of cranidium (on seven specimens); three pairs of glabellar furrows becoming progressively longer and more oblique posteriorly; occipital furrow and ring normal. Brim gently deflexed, unflared laterally and densely covered with anastomosing lines exactly as in Swedish species, brim:border ratio between 2 and 3; border elevated and well defined, slightly tapered laterally but thickened a little at center. Fixed cheeks flat, their width ratio between 3 and 4 (on seven specimens), palpebral lobes extending from opposite anteriormost to posteriormost glabellar furrow, centered on a line through middle glabellar furrow, quite anterior to glabellar midpoint; ocular ridges merge with palpebral lobes making them seem even larger; posterior limbs very poorly known since the single specimen preserving them is atypical in brim:border ratio, and possibly also in possessing narrower limbs than normal; limbs well furrowed.

Facial suture intramarginal not quite to center leaving dorsal surface about 0.75 distance from anterior corners to center, trending very slightly inward toward palpebral lobe and behind it outward at an unknown angle.

Free cheek very broad with a rim under eye and an evenly deflexed ocular platform marked with anastomosing lines; platform about 7 times width of well-marked elevated border. Genal spine moderately long.

Fragments of thoracic segments show a sharp lateral backward flexure characteristic of olenid trilobites.

Pygidium known only from a fragment

which shows a well-defined large axis with an anterior half ring, two segments, and a terminal segment. At least two segments with pleural grooves on convex pleural platforms; some evidence of a poorly defined border.

Discussion.—This species of *Parabolinella* has somewhat narrower posterior limbs than most of the Swedish and British species. They are of the nature of *P. leptoplastorum* (Westergård, 1947, p. 15, pl. 3, fig. 17). In general the brim:border ratio of *P. occidentalis* is less than in European species. The pygidium seems to agree with that of typical *Parabolinella* species.

The distinction between *Parabolina* and *Parabolinella* is given concisely in Lake (1909–1946, p. 63). The narrower fixed cheeks, long brim and border, less anterior position of the eyes, and non-spinose pygidium place the American species in *Parabolinella* instead of the former genus.

Occurrence.—With the *Conaspis* fauna of the upper Ore Hill member. Most abundant in a bed (47-5w.17) below *Taenicephalus* but this sequence should be demonstrated in other sections before conclusions are drawn as to range. 47-5w.17, 5w.34?, 47-10w.6.

Type.—YPM 18482, cran., 47-5w.17. Other specimens: YPM 18481, cran., 47-10w.6; YPM 18480, pyg., 47-5w.17; YPM 18479, free cheek, 47-5w.17.

Genus STIGMACEPHALUS Resser 1937
STIGMACEPHALUS ? DISTORTA
Wilson, n. sp.
Plate 92, figures 16, 17

Cranidium moderately convex, elongate excluding posterior limbs. Glabella tapered and rounded anteriorly, well defined by dorsal furrow slightly shallower in front than laterally; two faint pairs of glabellar furrows; occipital furrow weaker than dorsal, occipital ring poorly known, probably smooth. Brim occupying from 0.2 to 0.25 of axial length of cranidium, evenly declining to continue slight downward curvature of glabella; border lacking. Fixed cheeks flat, their width ratio from 4 to 5, bowed out at rather large anteriorly located palpebral lobes set off by a faint furrow; posterior limbs well furrowed, about as long as broad, lateral margins recurved.

Facial suture probably not intramarginal to center, trending slightly inward behind anterolateral corners and curving outward and backward behind palpebral lobes.

Discussion.—This species is known from several incomplete cranidia only one of which is undistorted. Comparison with type material of *Stigmacephalus oweni* (Hall) shows similar proportions. The form differs from the genotype in its recurved posterior limbs, slightly larger palpebral lobes, and more convex glabella. It is questionably assigned because of the poor and scant material.

Occurrence.—About 500 feet above the lower sandy member of the Conococheague formation, 47–27w.2, Antietam Battlefield; associated only with *Pseudosaratogia magna* in its highest occurrence; the only conaspid trilobite identified from the Conococheague.

Type.—YPM 18593, cran., 47-27w.2.

Genus TAENICEPHALUS Ulrich & Resser 1924
TAENICEPHALUS SHUMARDI (Hall)
Plate 95, figures 21–23, 25

Conocephalites shumardi HALL, 1863, 16th Ann. Rept., New York State Cab. Nat. Hist., p. 154, pl. 7, figs. 1, 2; pl. 8, figs. 19, 32.
Taenicephalus shumardi (Hall) ULRICH & RESSER, in Walcott, 1925, Smithsonian Misc. Coll., vol. 75, no. 2, p. 59, pl. 13, fig. 1.
Taenicephalus shumardi (Hall) ULRICH & RESSER, in Walcott, 1925, Smithsonian Misc. Coll., vol. 75, no. 3, p. 117, (?) pl. 17, figs. 15–17.
(?) *Taenicephalus shumardi* (Hall), SHIMER & SHROCK, 1944, Index fossils of North America, p. 633, pl. 266, fig. 17.

Eighteen "species" of *Taenicephalus* have been described by Resser (1942, pp. 99–106) disregarding both detailed stratigraphic occurrence and intrapopulational variation. Detailed biostratigraphic study in the Croixan area is needed to disclose limits of variability and evolutionary sequences of this and related conaspid genera. Numerous cranidia from the upper Ore Hill member compare closely with Hall's original types of the genotype, resembling them in having a brim: border ratio of about 1, a well-tapered triangular border and a tapered truncate glabella. In these the palpebral lobes are centered on a line through the middle pair of glabellar furrows anterior to the glabellar midpoint.

The pygidium assigned by Hall to *T.*

shumardi differs slightly from those so numerous with cranidia of the species in the Ore Hill member. These are relatively small and highly elevated with large axes bearing two or three rings and a terminal segment. The axis is about as wide as the pleural lobe. The pleural platform is steeply deflexed and bears two strong segments with well developed pleural furrows. The border is only moderately well defined.

Occurrence.—The most common trilobite in the *Conaspis* fauna of the upper Ore Hill member. 47–5w.32, 5w.36; 47–7w.1; 47–8 w. 7; 47–11w.2, 11w.4; 47–15w.5; 47–20w.5, 20w.6.

Figured specimens.—YPM 18577, cran., 47–20w.5; YPM 18574, pyg., 47–20w.6; YPM 18579, cran., 47–20w.6.

TAENICEPHALUS sp. undet.
Plate 95, figures 18, 24, 26

An isolated outcrop of the upper Ore Hill member, 47-14w.1, furnished parts of another *Taenicephalus* species. Lack of material prohibits a description but the parts are figured. The cranidium has an almost untapered border whose ratio with the brim is over 2. Pygidia from this collection show a well defined border. The figured free cheek is very plain and quite wide, possessing a rim around the eye, an ocular platform evenly deflexed to a rather shallow marginal furrow, and a somewhat thickened but narrow border which tapers sharply anteriorly and curves widely backward into a long drooping spine. The extension of the posterior limb furrow is deeper than the marginal furrow.

Figured specimens.—YPM 18573, cran., 47–14w.1; YPM 18576, pyg., 47–14w.1; YPM 18580, free cheek, 47–14w.1.

Genus WILBERNIA Walcott 1924
WILBERNIA sp. undet.
Plate 95, figures 27, 28

Several fragmentary cranidia agree with *Wilbernia diademata* (Hall) in lack of convexity, equi-sized brim and border, strong ocular ridges, and in the row of small pits in the arcuate marginal furrow. However, because the material is scanty and incomplete no specific identification is made. The keeled and rather well-furrowed glabella give the specimens a superficial resemblance to *Orygmaspis*.

Occurrence.—With *Taenicephalus* in the *Conaspis* fauna of the upper Ore Hill member, 47-5w.36, 47-8w.7, and 47-5w.17.

Figured specimens.—YPM 18432, cran., 47–5w.17; YPM 18587, cran., 47–8w.7.

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CAMBRIAN AND ORDOVICIAN FAUNAS OF EASTERN COLOMBIA

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ABSTRACT—Several faunules from eastern Colombia, mostly from Macarena, have yielded fossils from Middle Cambrian to Middle Ordovician beds. The forms are principally trilobites, brachiopods and graptolites, of which the first two groups are described; a few gastropods, cystids and cephalods also were found. New species are described of the trilobite genera *Basiliella ?*, *Ehmania*, *Kainella*, *Pseudokainella ?*, *Raphiophorus ?*, *Symphysurus*, *Westergardia ?*, and of the new genus *Tropidopyge*. *Geragnostus*, *Megalaspis* and *Niobella ?* are also present. Brachiopoda include *Acrotreta*, *Apheoorthis ?*, *Lingulella*, *Nanorthis ?*, and *Obolus ?*. Elements in the Colombian faunas have close affinities both with those of North America and Western Europe, and several of the species are very like those from Argentina. They include the first Cambrian fossils known from northern South America, as well as the largest Ordovician faunules that have been recognized.

INTRODUCTION

EARLY Paleozoic fossils have been recognized rarely in northern South America. Harrison (1930) and Botero-Arango (1940) reported Ordovician graptolites in central Colombia, and Leith (1938), a small Middle Ordovician faunule from Venezuela. In 1942, several collections made by geologists of the Shell Petroleum Company in eastern Columbia were sent by J. S. Williams to Marshall Kay with the request that approximate stratigraphic positions be determined. They yielded the first Cambrian fossils and the largest suite of Ordovician forms known from northern South America. The tentative identifications and associated stratigraphic data were published (Kay, in Trumpy, 1943). The faunules contained elements similar to those from northwestern Argentina (Harrington, 1938), so it seemed best that they be compared directly; Harrington thus restudied the trilobites and brachiopods, the final descriptions being prepared jointly. The present identifications supersede those made by Kay from the same material (Trumpy, 1943). Christina Lochman Balk gave useful advice on the specimens of *Ehmania*, and H. B. Whittington, on the genotype of *Protapatokephalus*. John D. Edwards and Gregory W. Webb assisted in the preparation of illustrations. Types have been deposited in the collections of Columbia University.

FAUNULES AND STRATIGRAPHIC CLASSIFICATION

The following faunules were collected by Dr. O. Renz along the Uribe Trail that crosses the Cordillera Orientale from the Magdalena River to the headwaters of the Guaviare River near 3° 20′ N. Lat. Northwest of Uribe, near the eastern end of the trail, loose boulders of gray, quartz-arenaceous, somewhat sheared limestone in a small tributary of the Rio Duda (Quebrada Agua Bonita) contained many trilobite fragments, collection R-356:

Ehmania akanthophora n. sp.
Ehmania (?) amphibola n. sp.

These clearly indicate a Middle Cambrian age. *Ehmania* seems to be represented by two species in the *Amecephalina* zone of western Argentina (Harrington and Leanza, 1943, p. 210).

A second faunule in silty argillite collected farther west along the trail on Cueva Creek, collection R-371, in gray argillite contained Ordovician graptolites tentatively identified (Kay, 1943) as *Didymograptus* sp. and *Tetragraptus* sp. J. C. Turner recently confirmd this identification, suggesting a probable Arenigian age for the fossils (private communication).

Several faunules were collected by Drs. A. Gansser and H. Hubach along the tributaries of the Guaviare River farther southeast in the Macarena range. In the

central Macarena on Caño Guapayito, dark gray, fine-textured limestone with abundant quartz grains and mica flakes yielded a large faunule, Za-81:

Acrotreta aequatorialis n. sp.
Lingulella sp. aff. *L. desiderata* (Walcott)
Nanorthis (?) sp.
Oxydiscus (?) sp.
Geragnostus tilcuyensis (Kayser)
Kainella colombiana n. sp.
Niobella (?) sp.
Parabolinopsis (?) sp.
Pseudokainella (?) *macarenae* n. sp.
Westergardia (?) *inornata* n. sp.

The faunule is Lower Tremadocian, and must be regarded as approximately equivalent in age to the *Kainella* fauna of northern Argentina and southern Bolivia. Besides a new species of that genus, the rock contains *Geragnostus tilcuyensis* (Kayser), a form heretofore known only from the Lower Tremadocian beds of southern Bolivia. *Pseudokainella*, a genus closely allied to *Kainella*, is represented by three species in the Lower Tremadocian of northern Argentina. *Parabolinopsis* is another Lower Tremadocian genus, heretofore restricted to southern Bolivia and northern Argentina, where it is represented by a single yet very frequent species. *Westergardia* is known only from the uppermost Cambrian *Acerocare* zone of Skåne, but its presence in Lower Tremadocian beds in Colombia need not be regarded as surprising, as several genera of "Cambrian olenids", such as *Parabolina*, *Protopeltura* and *Ctenopyge*, are well represented in the Lower Tremadocian of Argentina and Bolivia. Furthermore, the reference is only provisional, and better material may show that the species belongs to the closely allied genus *Cyclognathus*, frequent in the Lower Tremadocian beds of both Sweden and Argentina.

Some 25 kilometres to the southward, along "Caño 40½ km.," dark gray micaceous argillite yielded inarticulate brachiopods and graptolites in collection Za-144. The graptolites were identified by J. C. Turner who considers them as basal Llanvirnian (private communication):

Lingulella (?) sp.
Obolus (?) sp.
Dichograptus octobrachiatus (Hall)
Tetragraptus bigsbyi (Hall)

The same brachiopods were found in similar lithology along a creek to the south of Caño Guapaya, collection Za-81. Buff-weathering, cemented coarse quartz-arenite from an unstated locality in central Macarena, collection Hu-571, contained *Nanorthis* (?) *grandis* (Harrington), one of the most characteristic and frequent orthids in the Arenigian of Argentina, of a genus commonly represented in lowest Ordovician in North America.

In southern Macarena, locality Hu-612, along "Caño 60 km.," about 45 kilometres south of locality Za-81, gray argillite, quartz silty and micaceous, yielded:

Apheoorthis (?) sp.
Basiliella trumpyi n. sp.
Megalaspis sp. cf. *M. planilimbata* Angelin
Raphiophorus (?) *pyrus* n. sp.
Symphysurus metaensis n. sp.
Tropidopyge stenorhachis n. gen., n. sp.
Cystid plate
Bellerophontid gastropod
Orthoceracone cephalopod

The beds are probably Upper Tremadocian. *Megalaspis planilimbata*, though characteristic of the "*planilimbata*-kalk" of Scandinavia and the Baltic region, generally, is represented in the earlier *Apatokephalus* zone of Sweden. *Tropidopyge stenorhachis* is closely allied to *T.* ("*Dicelocephalus*") *bröggeri*, heretofore known only from the same zone and region. *Symphysurus*, although represented by a species in the higher Lower Tremadocian of Sweden is especially frequent in the *Shumardia* and *Apatokephalus* zones. *Basiliella*, on the other hand, though common in the Middle Ordovician Chikunsan beds of South Chosen and in the Chazyan and Bolarian (Black River age) of North America, has been recognized in Upper Tremadocian of Argentina.

Summarizing the six faunules, R-356 from the Uribe Trail seems Middle Cambrian. Za-81, from Caño Guapayito in central Macarena seems Lower Tremadocian, and Hu-612 from Caño 60 km. in southern Macarena seems Upper Tremadocian; Tremadocian rocks are generally classed as oldest Ordovician in Scandinavia and North America, but as Upper Cambrian in the type region in North Wales. The *Nanorthis*-bearing quartz-arenite from locality Hu-571 in central Macarena probably is basal Ordo-

vician Canadian in the North American classification, where they are associated with such trilobites as *Symphysurus*.

Faunule R-371 from the Uribe Trail is possibly Arenigian in the British chronology and basal Canadian in the North American, while Za-144 from central Macarena is basal Llanvirnian or Chazyan.

STRATIGRAPHIC CONCLUSIONS

The stratigraphic sections and faunas add to the knowledge of the structural development of Colombia in the early Paleozoic. One hundred meters or so of late Cambrian and early Ordovician sediments in central Macarena include well sorted quartz-arenites, as well as more argillaceous and calcareous rocks; they record deposition in a gradually subsiding, relatively stable region that was land in earlier Cambrian and retained Precambrian source land of low relief into the early Ordovician. The thickness increases to several hundred meters in northern Macarena, suggesting approach to a geosynclinal margin of undetermined trend. The presence of Middle Cambrian faunas northwest of Uribe may indicate that older Cambrian rocks thicken in this direction, and disappear southeastward toward the Macarena by onlap. The stratigraphy of the Macarena is analogous to that in North America from Wyoming and Montana westward, or from Sweden toward the Caledonides to the northwest. However, the lithologies in the geosynclinal belt are evidently preponderantly terrigenous; the miogeosyncline was not a broad, gently subsiding belt with thick carbonatites above basal quartz-arenites, as in western North America, but may contain detritus eroded from lands, perhaps tectonic welts, in the more mobile belts to the northwestward.

The trend of the geosynclinal belt (Weeks, 1947) is suggested in the similarity of Colombian faunas and lithologies to those southward through eastern Peru (Newell and Tafur, 1944) and Bolivia (Lake, 1906; Steinmann and Hoeck, 1912) into northwestern Argentina (Harrington, 1938). Though one might be tempted to draw direct connections from Colombia to Maritime Canada, where there are similar faunas (Hayes and Howell, 1937, p. 93–9), and thence to Wales and Scandinavia, the faunal similarities evidence comparable ecology within a relatively long time; the faunas may have been able to migrate far by quite devious and complicated routes through the millions of years through which they range, as is suggested further by approximate but not identical succession of genera in the two hemispheres (Harrington and Leanza, 1943). Possibly the geosynclinal belt trended along the Appalachian and Ouachita orogenic belts to Colombia through the course of the present Antilles (Kay, 1948). The fossils in the Cambrian include genera common to both the western or Pacific, and eastern or Atlantic provinces of North America and western Europe.

SYSTEMATIC DESCRIPTIONS

BRACHIOPODA

Family OBOLIDAE King

Genus OBOLUS Eichwald

OBOLUS (?) sp.

Plate 97, figure 1

A single valve has a subtriangular-rounded outline, is gently convex; surface with very fine, somewhat irregular lines of growth crossed by extremely fine radiating striae; internal characters unknown, but general shape and sculpture suggest reference to *Obolus*.

Locality.—Za-144, Caño 40½ tributary, Central Macarena. Llanvirnian. Single valve.

Illustrated specimen.—25921.

Genus LINGULELLA Salter

LINGULELLA (?) sp.

Plate 97, figure 4

Three detached valves associated with *Obolus* (?) sp. indet. The valves probably ventral, elongated and subovate, rather acuminate and flattish; surface with numerous fine lines of growth but lacks radial striae. As internal characters are unknown, reference to *Lingulella* is provisional.

Locality.—Za-144, Caño 40½ tributary, Central Macarena. Llanvirnian. Several specimens.

Illustrated specimen.—25922.

Genus LINGULELLA Salter

LINGULELLA sp. aff. L. DESIDERATA (Walcott)

Plate 97, figures 2 and 3

1943. *Lingula* sp. cfr. *Obolus elongatus* KAY, in Trumpy, p. 1287.

Shell small, subovate, with the ventral valve acuminate and the dorsal valve broadly ovate and rather straight anteriorly, each valve moderately convex. Surface having fine concentric lines of growth crossed by numerous extremely fine radiating striae. One ventral valve has somewhat crushed umbonal region causing outline of moderately broad pedicle groove to stand out. Internal characters unknown. Length of ventral valve 5 mm.

The shells agree in general shape and external characters with *Lingulella desiderata* (Walcott) from the Upper Cambrian of North America (Walcott, 1912, p. 492, pl. 20, figures 5b and 5c especially), but seem to differ in their lesser convexity and broader pedicle groove on the ventral valve.

Locality.—Za-81, Caño Guapayito, Central Macarena. Lower Tremadocian. Several valves.

Illustrated specimens.—25925 (ventral), 25926 (dorsal).

Family ACROTRETIDAE Schuchert

Genus ACROTRETA Kutorga

ACROTRETA AEQUATORIALIS, Harrington & Kay, n. sp.

Plate 97, figure 8

1943. *Obolus* sp. cfr. *Obolus salteri* KAY, in Trumpy, p. 1287.

Dorsal valve small, subcircular in outline and moderately convex. Median septum narrow and comparatively short, extending to about midway between posterior and anterior margins. Cardinal scars of medium size, somewhat elongated and oblique. Central scars minute and elongated, branching off from the anterior half of septum.

External surface apparently covered by fine concentric lines. Ventral valve unknown. Length of dorsal valve 2.5 mm.

This form, although known by a single dorsal interior, can be easily distinguished from all the known species of this genus. Compared with *Acrotreta* sp. cfr. *A. curvata* Walcott of Kobayashi from the Lower Tremadocian of Bolivia (Kobayashi, 1937, p. 417, pl. 1, figures 3 and 4), the Colombian specimen has much less developed central scars and a shorter septum. From *Acrotreta iruyensis* Harrington (1938, p. 123, pl. 1, figures 11 and 16), it is easily distinguished by its subcircular outline.

Locality.—Za-81, Caño Guapayito, Central Macarena. Lower Tremadocian. Single interior.

Holotype.—25927.

Family BILLINGSELLIDAE Walcott & Schuchert

Genus APHEOORTHIS Ulrich & Cooper

APHEOORTHIS (?) sp.

Plate 97, figure 5

1943. *Apheoorthis* (?) sp. KAY, in Trumpy, p. 1287.

A single small internal cast of a dorsal valve seems to belong to a species of *Apheoorthis*. Although fragmentary, the specimen seems to have its maximum width along the hinge-line. The shell is covered by sharply angular costae which seem to increase in number by bifurcation; finer details of the sculpture are not preserved; valve broadly sulcate. Brachiophores are small, cardinal process barely visible and there is no notothyrial platform.

The shell is like some of the specimens of *Apheoorthis* from the Manitou limestone figured by Ulrich and Cooper, especially *Apheoorthis bella* Ulrich and Cooper (Ulrich and Cooper, 1938, p. 80, pl. 9, figures 14, 15, and 9).

Locality.—Hu-612, Southern Central Macarena. Upper Tremadocian.

Illustrated specimen.—25928.

Family ORTHIDAE Woodword

Genus NANORTHIS Ulrich & Cooper

NANORTHIS (?) sp. cf. EOORTHIS GRANDIS Harrington

Plate 97, figures 9 and 10

1938. *Eoorthis grandis* HARRINGTON, p. 129, pl. 2, figs. 12, 15, 17, 18.

1938. *Nanorthis saltensis* ULRICH & COOPER (non Kayser) p. 91, pl. 12, figs. E. 15–18.

1943. *Archaeorthis* sp. cf. *Eoorthis grandis* KAY, p. 1289.

Several fragments of a light yellowish, coarse-grained friable sandstone are covered by internal and external casts of a fairly large orthid which seems to agree with *Nanorthis grandis* (Harrington) from the Skiddavian of northern Argentina (Harrington,

1938, p. 129, pl. 2, figs. 12, 15, 17 and 18). The matrix is, unfortunately, too coarse and the finer details of the internal characters are not clearly observable; external sculpture is closely similar, as well as the general outline and size.

Locality.—Hu-571, Central Macarena. Lower Ordovician. Many specimens.

Illustrated specimens.—25929–30.

NANORTHIS (?) sp.
Plate 97, figures 6 and 7

1943. "*Orthis*" sp. cfr. *Finkelnburgia samensis* KAY, in Trumpy, p. 1287.

Several very small shells belong to an orthid which could represent a species of *Nanorthis*. The ventral valve appears to be considerably more convex than the dorsal, which is almost flat. None of the specimens show internal details. The external sculpture consists of a few, comparatively coarse and bifurcating radial ribs.

Locality.—Za-81, Caño Guapayito, Central Macarena. Lower Tremadocian.

Illustrated specimens.—25931–32.

AGNOSTIDA
Family AGNOSTIDAE M'Coy
Genus GERAGNOSTUS Howell
GERAGNOSTUS TILCUYENSIS (Kayser)
Plate 96, figure 18

1876. *Agnostus tilcuyensis* KAYSER, pl. 1, fig. 6–9.
1937. *Geragnostus tilcuyensis* KOBAYASHI, p. 379, text-fig. 1–4 (reproduction of Kayser's figures).

A single complete specimen from Caño Guapayito seems to belong to *Geragnostus tilcuyensis* (Kayser) heretofore known only from the Lower Tremadocian of southern Bolivia. Kayser's original description and figures are wholly inadequate to characterize this species, which was tentatively referred to *Geragnostus* by Kobayashi. Fortunately, however, Kayser's types are kept in the collections of the Geological Department of Buenos Aires University, and a direct comparison was possible. Under these circumstances it seems advisable to redescribe Kayser's types, as otherwise the Colombian specimens could not be correctly identified.

The following description is based on Kayser's types from Tilcuya, southern Bolivia:

Cephalon small, very convex, subcircular in outline to very slightly elongated, with well-defined narrow border. Cheeks smooth, of uniform width and confluent. Glabella elevated above the cheeks, slightly conical and evenly rounded in front; width is just more than one-third total width of cephalon. Anterior lobe well defined by straight or very slightly curved transglabellar furrow, length about one-third that of glabella; main lobe with tiny, barely visible mesial node; basal lobes triangular, small.

Pygidium small, about same size as cephalon, very convex, with narrow border and (apparently) without marginal spines. Pleural lobes smooth, narrowed behind axis but confluent. Axis wide and elevated over the pleural lobe, its width about one-half total width of shield. Anterior segment formed by pair of small, lateral subtriangular lobes; median segment somewhat longer, carrying a well-defined, elongated mesial tubercle, rear segment evenly rounded behind, its length that of first two segments. Length of cephalon 2 mm., length of pygidium 2 mm.

This species is very similar to *Geragnostus holmi* Westergård (=*Agnostus rudis* var. *holmi* Westergård) from the *Peltura* zone of the Upper Cambrian of Sweden (Westergård, 1922, p. 118, pl. 1, figures 13–16), but it can be distinguished from the Scandinavian form by its somewhat longer anterior glabellar lobe, shorter and longer rear pygidial segments and less globose pygidium.

The Colombian specimen seems to be indistinguishable from the Tilcuya species when allowance is made for the different matrix, sandstone at Tilcuya and shaly parting at Caño Guapayito.

Locality.—Zu-81, this species is known from Tilcuya (southern Bolivia) and Caño Guapayito in Central Macarena in Lower Tremadocian beds. Single carapace.

Lectotypes here designated.—Departamento de Geologia, Universidad de Buenos Aires (Argentina) Nos. 2562 and 2563; *Illustrated specimen*: Columbia University 25933.

TRILOBITA
Family RAPHIOPHORIDAE Angelin
Genus RAPHIOPHORUS Angelin
RAPHIOPHORUS (?) PYRUS
Harrington & Kay, n. sp.
Plate 97, figures 11–13

1943. *Ampyx* sp. aff. *Ampyx linnarssoni* KAY, in Trumpy, p. 1287.

Cranidium small, transversely elongated

and semielliptical in outline. Glabella ovate, strongly convex and elevated over the fixed cheeks; surface smooth, without trace of glabellar furrows, spine or tubercle; occipital ring narrow and straight. Fixed cheeks gently convex, with narrow posterior furrow and border. Brim distinct but narrow. Anterior margin narrower than brim. Pygidium subrounded-triangular. Axis conical, with about five or six narrow and straight rings and a terminal segment. Pleural lobes practically smooth, with very faint traces of a straight anterior segment. Length of cranidium 2.5 mm., width 6 mm. Length of pygidium 3 mm., width 10 mm.

The Colombian specimens differ from all the known species of Raphiophoridae in the absence of glabellar spine or tubercle. This feature, however, may be due to the fact that all three specimens available are internal casts.

Our form can be compared with *Raphiophorus semicostatus* (Billings) as described and figured by Raymond from the *Lingula* shales of Newfoundland (Raymond, 1925, p. 31, pl. 1, figs. 14 and 15); that species, as illustrated in figure 14, has a well developed glabellar spine; when the test is broken, however, the spine disappears and no trace can be detected in the internal cast, as shown in Raymond's figure 15. *R.* (?) *pyrus* seems to differ from Billings' species in the shape of the glabella, which is less expanded anteriorly, and in the less convex fixed cheeks. The pygidium, moreover, has practically smooth pleural lobes while *Raphiophorus semicostatus* shows five or six well-marked pleurae.

This species can be also compared with *Ampyx nudus* (Murchison) from the Llandeilo flags of Wales (Murchison, 1839, p. 660, pl. 23, figure 5), but this species has a more semicircular cranidium, more elongated glabella and segmented pleural lobes on the pygidium.

Locality.—Hu-612, Southern Central Macarena (Upper Tremadocian). Single cranidium and pygidium.

Holotype.—25934; paratypes: 25935 (cranidium), 25936 (pygidium).

Family KAINELLIDAE Ulrich & Resser

Genus KAINELLA Walcott

KAINELLA COLOMBIANA Harrington & Kay, n. sp.

Plate 96, figures 11 and 12

1942. *Kainella meridionalis* KAY (non Kobayashi), in Trumpy, p. 1287.

Cranidium transversely elongated, two-thirds as long as wide, gently convex longitudinally. Glabella slightly longer than wide, almost flat, truncated anteriorly and somewhat at the middle. Dorsal furrows deep, slightly diverging forwards from occipital furrow to midlength of the glabella, then gently inwards and slightly convergent to preglabellar furrow. Glabella marked by three pairs of lateral glabellar furrows, disconnected at the middle; furrows deep and broad, those of the last pair strongest, first two pairs not touching dorsal furrows. Occipital ring wide and straight, well differentiated by deep occipital furrow. Width of brim about one-half the length of the glabella (without occipital ring). Brim slightly convex and gently sloping forward, crossed by irregular radiating ridges. Border elevated, about one-half the width of the brim, marked by a deep marginal furrow with a row of some 25 minute pits. Eyes large, somewhat elongated and placed very near to the glabella and quite posteriorly, extending from the posterior marginal furrow to the first glabellar furrow; Palpebral furrows sharply convex. Anterior branch of the facial suture strongly divergent in front of the eyes, directed very obliquely outwards.

This species resembles *Kainella meridionalis* Kobayashi from the Lower Tremadocian of Argentina (1935, p. 64, pl. 11, fig. 5–7) but has a shorter glabella, somewhat constricted anteriorly. The lateral glabellar furrows are more deeply marked than in the type material illustrated by Kobayashi which is, however, preserved in a rather coarse sandstone. Better cranidia, preserved in shale, show two pairs of fairly deep posterior furrows and faint traces of a weak anterior pair.

The shape of the glabella resembles that of *Kainella conica* Kobayashi, also from the Lower Tremadocian of Argentina (1935, p. 65, pl. 11, fig. 16–17) but this species has

much narrower brim and palpebral lobes. *Kainella billingsi* (Walcott), the genotype (1924, p. 102, pl. 22, fig. 1–7) has a longer, faintly segmented glabella and much smaller eyes. *Kainella orientalis* Rasetti, from the Lower Ordovician of eastern Canada (1943, p. 102, pl. 19, fig. 12) has subquadrate glabella with only faint traces of two pairs of lateral furrows.

The species also resembles *Richardsonella megalops* (Billings) (Rasetti, 1944, pl. 39, figs. 48–49), genotype of *Richardsonella*. The genera have very similar cephalons, though strongly contrasting pygidia. The glabella of *Kainella* seems more rectangular, but with more sinuous dorsal furrows; the strength of glabellar furrows, relative width of brims, sizes of palpebral lobes, and divergence of anterior branches of facial sutures vary considerably among assigned species.

Locality.—Za-81, Caño Guapayito, Central Macarena, Lower Tremadocian. Single cranidium.

Holotype.—25937.

Genus PSEUDOKAINELLA Harrington

PSEUDOKAINELLA (?) MACARENAE Harrington & Kay, n. sp.

Plate 96, figures 19–21

1943. *Kainella* sp. cfr. *Kainella lata* KAY, in Trumpy, p. 1287.

Cranidium small and gently convex, transversely elongated, two-thirds as long as wide. Greatest width along posterior limbs. Glabella (without occipital ring) about as long as wide, elevated over free cheeks and gently convex longitudinally; truncated-subrounded in front and somewhat expanded in posterior third; dorsal furrows deep, gently convex outwards in posterior two-thirds and slightly convergent in anterior third.

Glabella marked by one pair (posterior) of lateral glabellar furrows in the shape of oblique shallow depressions, some specimens show vague traces of another pair. Occipital ring wide, expanded at middle due to central curvature of occipital furrow.

Width of brim about one-fifth length of glabella (without occipital ring). Brim flat longitudinally and convex transversely, crossed by very faint and indistinct radiating ridges. Border elevated, convex, about same width as brim. Anterior marginal furrow with row of minute pits. Anterior margin curved forwards, with very gentle mesial angle or point. Eyes large, long, placed close to the glabella and quite posteriorly, extending from the posterior marginal furrow to the anterior third of glabella. Posterior limb of fixed cheek very narrow and long. Anterior branch of facial suture strongly divergent in front of the eyes, directed very obliquely to lateral border, then curving and cutting border very obliquely to center, meeting on dorsal face of shield. Length of cranidium, 6 mm., maximum width (measured at posterior limbs), 9 mm.

This species may be compared with the single cranidium from the Lower Tremadocian of Argentina, illustrated by Kobayashi as *Kainella lata* Kob. (1935, p. 65, pl. 11, fig. 18) but it has a wider brim and somewhat more arcuate frontal margin.

In a forthcoming paper by Harrington and Leanza on the Ordovician trilobites of Argentina it will be shown that Kobayashi's species belongs to the genus *Pseudokainella* Harrington. In 1935, Kobayashi illustrated, besides the cranidium of *K. lata*, several cranidia and pygidia from the same locality which he referred to a new genus and species of olenid, *Andesaspis argentinensis* Kobayashi (1935, p. 67, pl. 11, fig. 1–4). The pygidia of "*Andesaspis*" cannot, obviously, belong to an olenid, being reminiscent of *Apatokephalus*. The discovery of complete and well-preserved specimens having a "*lata*" cranidium and an "*Andesaspis*" pygidium shows at once that they belong to a single species and that this species, though a kainellid, is not referable to *Kainella* Walcott as the pygidia are obviously quite different. The form, on the other hand, is closely comparable with *Pseudokainella keideli* Harrington, the genotype of *Pseudokainella* (1938, p. 174, pl. 5, fig. 11–15).

Whether the Colombian specimens truly belong to *Pseudokainella* or whether they may be referable to *Kainella* is difficult to decide as no pygidia are available and the cranidia show rather intermediate features.

Locality.—Za-81, Caño Guapayito, Central Macarena, Lower Tremadocian. Several cranidia.

Holotype.—25938: paratypes; 25960–61.

Family OLENIDAE Burmeister
Genus WESTERGARDIA Raymond
WESTERGARDIA (?) INORNATA
Harrington & Kay, n. sp.
Plate 96, figure 10

1943. *Shumardia* (?) sp. KAY, in Trumpy, p. 1287.

Cranidium very small, semicircular in outline, twice as wide as it is long. Glabella slightly longer than wide, very gently conical and evenly rounded in front, moderately convex and raised over the fixed cheeks. Surface smooth. Dorsal furrows deep, rather wide posteriorly and narrow anteriorly, convergent towards the front. Occipital furrow straight. Occipital ring somewhat wider at the middle. Brim narrow but distinct, slightly convex and sloping forwards and downwards. Border either absent or not preserved in the specimens at hand. Anterior margin straight or very gently curved. Fixed cheeks wide and convex. Posterior limbs large and triangular, with straight posterior marginal furrow. Eyes unknown. Length of cranidium 1 mm; width, 1.6 mm.

The cranidia just described, although very small, must be considered as belonging to adult individuals as no trace of glabellar segmentation is observed in any of them.

They are probably best compared with some of the known species of *Westergardia* Raymond from the *Acerocare* zone of Sweden, but as the eyes are unknown in our specimens, the reference to this genus must be provisional. The Colombian cranidia recall those of *Westergardia illaenopsis* (Westergård) (Westergård, 1944, p. 43, pl. 3, figures 17 and 18 especially) and even more so some of the specimens originally referred by Westergård to "*Boeckia*" *illaenopsis* (Westergård, 1922, pl. 16, figures 33 and 34) but later considered by him as probably belonging to a distinct species (1944, p. 43, synonymy). *Westergardia*, however, seems to have a somewhat more conical glabella and narrower brim. Our specimens are also comparable to *Cyclognathus* which, according to Raymond, is closely allied to *Westergardia*, but in this genus the eyes are very anterior and even when not preserved, the cranidium has a decidedly trapezoidal outline. The Colombian cranidia are not unlike those of *Shumardia*, but the shape of the glabella precludes reference to that genus.

Locality.—Za-81, Caño Guapayito, Central Macarena. Lower Tremadocian. Several cranidia.

Holotype.—25939.

Genus PARABOLINOPSIS Hoek
PARABOLINOPSIS (?) sp., pygidia
Plate 96, figures 13, 15, 16

1943. cfr. *Peltura* sp. KAY, in Trumpy, p. 1287.

Several small pygidia, mostly rather poorly preserved, probably belong to *Parabolinopsis* Hoek, though they could belong to *Peltura* Milne Edwards or *Protopeltura* Brögger.

The best pygidium has a semielliptical outline, being almost three times as wide as long; axis short and broad, showing two narrow rings and a bounded posteriorly terminal segment; first ring strongly bent forward. Pleural lobes carry two pleurae, transversed by oblique and wide pleural furrows; pleurae bent near margin and ending in indeterminate number of sharp spines directed posteriorly. Length of pygidium, 3, 4, mm., width, 8, 7 mm.

The pygidia are provisionally attributed to *Parabolinopsis* because of their close similarity with that of the genotype, *Parabolinopsis mariana* Hoek, from the Lower Tremadocian of southern Bolivia and northern Argentina.

Hoek's type material (1912, p. 226, pl. 7, figures 1–3) reillustrated by Kobayashi (1937, p. 479, pl. 4, figures 15–17) does not show the pygidium, but Harrington and Leanza have been able to prove that the form described by Harrington as *Protopeltura granulosa* (1938, p. 213, pl. 8, figures 13, 18 and 21) is identical with Hoek's species. The pygidium, excellently preserved in many complete specimens, is characterized by its transverse outline, two axial rings, rounded terminal segment and two pleurae ending in spines, just as in the Colombian shields. This is, however, a rather generalized pelturid type not unlike that of *Protopeltura praecursor* (Westergård) (1922, p. 171, pl. 14, figure 29 especially) and *Peltura planicauda* Brögger (1882, pl. 2, figure 8).

The presence of the several pygidia with cephala assigned to *Kainella* and *Pseudokainella ?* led to the attempt to associate the

pygidia with one of those genera. However, they lack the posterior axial keel that seems characteristic of kainellids. The pygidia somewhat resemble those of *Richardsonella arctostriatus* (Raymond) (Rasetti, 1944), though shorter and less spinose.

Locality.—Za-81, Caño Guapayito, Central Macarena. Lower Tremadocian. Several pygidia.

Illustrated specimens.—25940, 25955.

Family ILLAENURIDAE Raymond
Genus SYMPHYSURUS Goldfuss
SYMPHYSURUS METAENSIS
Harrington & Kay, n. sp.
Plate 97, figures 19, 20

Pygidium of medium size, gently convex, semielliptical in outline and about twice as broad as it is long. Axial lobe narrow, conical and short. Its anterior width equals about one-sixth the total width of the tail and its length is just over half the length of the shield. Axis gently elevated over pleural lobes, tapering backwards and bluntly pointed at the rear. The anterior half of the lobe bears traces of three rings, but the posterior half is practically devoid of segmentation. Pleural lobes gently convex and sloping downwards. Facet strong. Anterolateral angles broadly rounded. Faint traces of two interpleural (?) furrows may be seen at the anterocentral part of the pleural lobes. The pleural lobes end in a wide flat border which is not sharply defined. A very fragmentary cranidium shows a large eye and a little defined glabella which expands forward. Length of pygidium, 8 mm., width, 17 mm.

The specimens can be compared with *Symphysurus angustatus* Sars and Boeck as figured by Moberg and Segerberg from the *Apatokephalus* zone of Ottenby (Moberg and Segerberg, 1906, p. 90, pl. 5, figures 16, 20, and 21 especially). The Colombian pygidium has rounded anterolateral angles and a narrower axial lobe, while faint traces of segmentation are still retained by the pleural lobe. In this last character it resembles *Symphysurus croftii* (Callaway) (Brögger, 1882, p. 58, pl. 1, figure 2), from the *Symphysurus* zone of Töien. The fragmentary cranidium shows large eyes, also comparable to those of *Symphysurus angustatus*.

Locality.—Hu-612, Southern Central Macarena, Upper Tremadocian. Single cranidium and pygidium.

Holotype.—25956 (pygidium); *paratype*: 25941 (cranidium).

Family DIKELOCEPHALIDAE Miller
Genus TROPIDOPYGE
Harrington & Kay, n. gen.

Pygidium of medium size, gently convex, subelliptical in outline and slightly wider than long. Axial lobe conical, with postaxial keel reaching the posterior margin. Pleural lobes marked by few short pleurae without pleural furrows. Flat border wide and ill defined. No pygidial spines. The distinctive character is the narrow post-axial keel.

Holotype: *Dikelocephalus bröggeri* Moberg and Segerberg (1906, p. 87, pl. 5, figures 7 and 8); the cephalon is not known, so that the name may be a synonym of one based on an unassociated cephalon. The lectotype pygidium is that figured on plate 5 as figure 7, being No. LO 1836 in the Museum of the Paleontological Institute, Lunds University; the specimen is from the *Ceratopyge* beds at an unstated one of the few exposures of the beds at Ottenby, on the west coast of southern Oeland, Sweden. The original cotype pygidium is No. LO 1837. The Swedish material is selected as genotype because of the accessibility of the type locality.

TROPIDOPYGE STENORHACHIS
Harrington & Kay, n. sp.
Plate 97, figure 22

Pygidium of medium size, gently convex both longitudinally and transversely, subelliptical in outline and slightly wider than long. Axial lobe slightly raised over the sides, narrow and conical, bluntly pointed behind. At the anterior its width equals about two-sevenths the total width of the shield but at the point where the maximum width of the pygidium is measured, the axial lobe is only one-ninth of that measure.

Axial lobe practically smooth, with very faint traces of segmentation near its anterior end, and prolonged backwards into narrow postaxial keel reaching the posterior margin.

Pleural lobes gently convex and sloping downwards, marked by four faint pleurae.

The first interpleural groove is stronger than the others. The pleurae are short, straight, very oblique outwards and backwards and devoid of pleural furrows. They gradually disappear at the wide depressed border which is made evident only by a change in the slope.

Length of pygidium, 15 mm., width, 18 mm.

The pygidium closely resembles those identified by Moberg and Segerberg as *Dikelocephalus bröggeri* from Ottenby. The following observations were made by Dr. Gerhard Regnell of Lunds University from comparisons of the genotypes with photographs of the Colombian specimens:

> The width-length ratios are 1.3 and 1.2, respectively. In general appearance the specimens have a good deal in common but the greatest width of the pygidium lies farther back in the Swedish form which is not as much pointed as the Colombian one. The rhachis seems to have greater relative width in the Swedish species and to be shorter; it is broadly conical, its length being about one-half of the entire length of the pygidium; its sides are almost straight, whereas they seem to be clearly concave in your species; a faint keel seems to run from the tip of the rhachis to the posterior margin of the pygidium in both forms. I cannot recognize the number of rings of the rhachis in your specimen; the Swedish form has six. The lateral pleurae seem to be fairly similar.
>
> Your specimen is not convincingly congeneric with *Dikelocephalus bröggeri* but is likely to belong to a related genus.

These pygidia cannot be placed in the genus *Dikelocephalus* Owen, and Walcott, in 1914, suggested that they could belong to *Platycolpus* Raymond (Walcott, 1914, page 349). This genus, however, as shown by the genotype *Platycolpus* ("*Bathyurus*") *capax* (Billings) (Raymond, 1913, p. 63, pl. 8, figure 21) has a much wider pygidium of quite different aspect; moreover, *Platycolpus* Raymond 1913 is an invalid homonym of *Platycolpus* Donald 1900 (mollusca).

The Colombian specimen, as well as the Scandinavian ones, also may be compared with the form identified by Bulman as *Saukia* (?) sp. from the Llanvirnian of Bolivia (Bulman, 1931, p. 90, pl. 10, figure 14 and pl. 11, figure 5). Bulman drew attention to the similarity between the pygidium of his *Saukia* (?) sp. and those figured by Moberg and Segerberg, but pointed out that the Bolivian specimens have furrowed pleurae. Besides this character, *Saukia* (?) sp. has no depressed border, the interpleural grooves extending almost to the margin, while the postaxial keel is decidedly shorter and less distinct. *Saukia* (?) sp. belongs to yet another genus, represented in the Skiddavian of northern Argentina by a large species which will be described by Harrington and Leanza.

Locality.—Hu-612 Southern Central Macarena (Upper Tremadocian). Pygidium.

Holotype.—25942.

EXPLANATION OF PLATE 96

Illustrations have magnification of about six times, unless otherwise indicated.

FIGS. *1–9*—Middle Cambrian from Locality R-356, Uribe Trail, Eastern Cordillera, Colombia.

1–5—*Ehmania akanthophora*, n. sp., Cranidia. *1*, *2*, Holotype 25950. *3*, *4*, *5*, Paratypes 25948, 25949, 25947. (p. 666)

6–9—*Ehmania ? amphibola*, n. sp., Cranidia. *6*, *7*, Holotype 25951. *8*, *9*, Paratypes 25952, 25953. (p. 667)

FIGS. *10–24*—Lower Tremadocian from Locality Za-81, Central Macarena, Colombia.

10—*Westergardia ? inornata*, n. sp., Cranidium, Holotype 25939. (p. 662)

11–12—*Kainella colombiana*, n. sp., Cranidium, Holotype 25937; *12*, reversed in illustration; ×1½ (p. 660)

13, *15*, *16*—*Parabolinopsis ?* sp., Pygidia. *13*, *15*, exterior and interior, 25940, *16*, exterior, 25955; ×4. (p. 662)

14—Unidentified trilobite libragene, 25954, associated with *Pseudokainella ? macarenae*; ×3. (p. 661)

17—*Oxydiscus ?* sp. Specimen 25957; ×5. (p. 667)

18—*Geragnostus tilcuyensis* (Kayser). Plesiotype 25933. (p. 659)

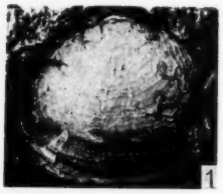
19–21—*Pseudokainella ? macarenae*, n. sp., Cranidia. *19*, Holotype 25938. *20*, *21*, Paratypes 25960, 25961. *19* and *20*, ×4; 21, ×6. (p. 661)

22—Unidentified trilobite pygidial fragment, possibly of *Pseudokainella* sp. Specimen 25962; ×2. (p. 661)

23—*Niobella ?* sp., Pygidium. Specimen 25946; ×5. (p. 666)

24—Unidentified trilobite cranidial fragment. Specimen 25963; ×1½.

Harrington and Kay, Colombian Cambro-Ordovician fossils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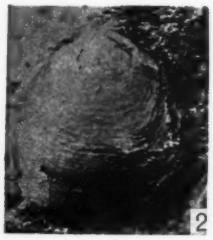
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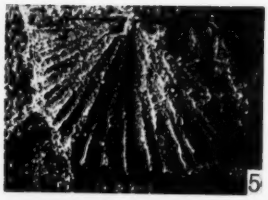
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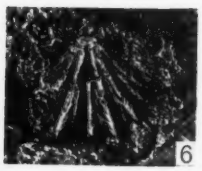
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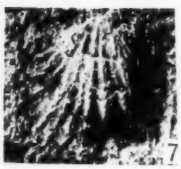
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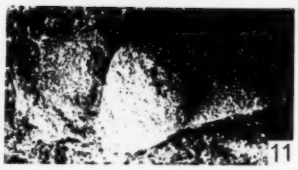
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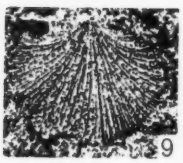
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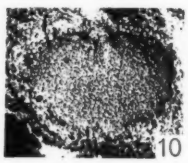
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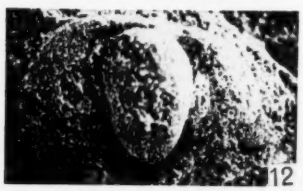
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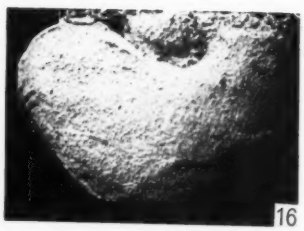
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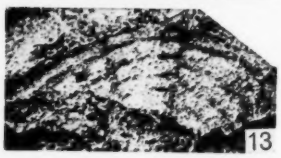
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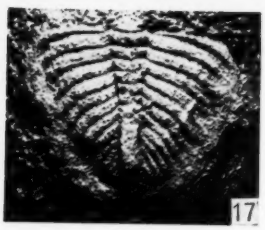
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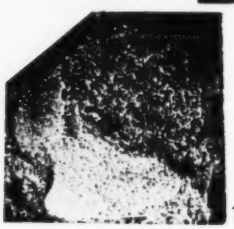
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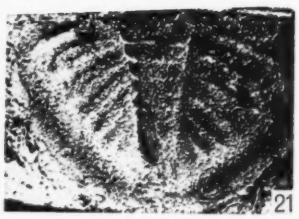
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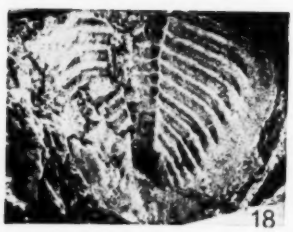
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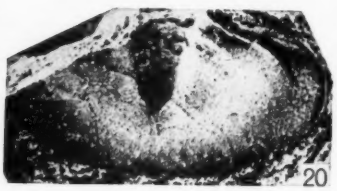
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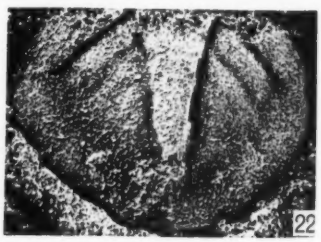
22

Harrington and Kay, Colombian Cambro-Ordovician fossils

Family ASAPHIDAE Emmrich
Genus MEGALASPIS Angelin
MEGALASPIS sp. cf. M. PLANILIMBATA Angelin
Plate 97, figure 21

1943. *Megalaspis* sp. cf. *M. planilimbata* KAY, in Trumpy, p. 1287.

Pygidium small, gently convex and parabolic in outline. Its length equals about two-thirds its maximum width.

Axial lobe narrow, conical and gently raised over the pleural lobes; anterior width about one-fifth total width of shield; axial lobe bears seven straight rings, well marked near the anterior end but becoming obscure to rear; lobe ends in a terminal smooth segment, rounded behind.

Pleural lobes marked by six straight costae, separated by deep interpleural grooves. The costae abruptly end at the rather wide and conspicuous concave border.

Length of pygidium, 10 mm., width, 15 mm.

Remarks.—The pygidia just described may be compared with those of *Megalaspis planilimbata* Angelin figured by Schmidt from the B2a stage of Estonia (Schmidt, 1906, p. 10, pl. 1, figure 1 and 2 and pl. 2, figure 4 especially). They differ in having fewer segments both in the axial and pleural lobes. In this they are very similar to the pygidia figured by Wiman from the *Shumardia* beds of Nerike (Wiman, 1905, p. 8, pl. 12, figure 10 especially) and by Moberg and Segerberg from the *Apatokephalus* zone of Ottenby (Moberg and Segerberg, 1906, p. 97, pl. 7, figure 1). These pygidia are much smaller and have fewer segments than the Baltic specimens. Moreover, the segmentation of the axial lobe becomes obsolete towards the rear, much as in the Colombian specimens.

Under the circumstances, and without knowing the cephalic characters, we have provisionally referred the Colombian specimens to Angelin's species.

Locality.—Za-81, Southern Central Macarena, Upper Tremadocian. Two pygidia.

Illustrated specimen.—25943.

Genus BASILIELLA Kobayashi
BASILIELLA TRUMPYI Harrington & Kay, n. sp.
Plate 97, figures 17 and 18

1943. *Megalaspis* sp. cfr. *M. extenuata* KAY, in Trumpy, p. 1287.

Pygidium large, parabolic and flattened, maximum width about one-fourth greater than length. Axial lobe narrow, long and conical, anterior end about one-sixth width of the tail, axis flat along anterior but raised above pleural lobes at posterior; anterior

EXPLANATION OF PLATE 97

Illustrations have magnification of about six times, unless otherwise indicated.

FIGS. *1–10*—Lower Tremadocian and Arenigian from localities in the Macarena, Colombia.
1—*Obolus ? sp.* Dorsal valve; 25921. Loc. Za-144; Arenigian, ×4. (p. 657)
2, 3—*Lingulella* sp. aff. *L. desiderata* (Walcott). Loc. Za-81; Lower Tremadocian. *2*, Dorsal valve; 25926. *3*, Ventral valve, 25925. (p. 658)
4—*Lingulella ?* sp. Ventral valve; 25922. Loc. Za-144; Arenigian. (p. 657)
5—*Apheorthis ?* sp. Dorsal interior mold; 25928. Loc. Hu-612; Arenigian. (p. 658)
6, 7—*Nanorthis ?* sp. Loc. Za-81; Lower Tremadocian. *6*, Dorsal valve; 25931. *7*, Ventral valve; 25932. (p. 659)
8—*Acrotreta aequatorialis* Harrington & Kay, n. sp. Dorsal interior mold; Holotype 25927. Loc. Za-81; Lower Tremadocian. (p. 658)
9, 10—*Nanorthis ?* sp. cf. *Eoorthis grandis* Harrington. Loc. Hu-571; Arenigian. *9*, Dorsal external mold; 25929. *10*, Dorsal internal mold; 25930; ×1½. (p. 658)

FIGS. *11–22*—Arenigian from Locality Hu-612, Central Macarena, Colombia.
11–13—*Raphiophorus ? pyrus* Harrington & Kay, n. sp. *11–12*, Cephalon; Holotype 25934. *13*, Pygidium, Paratype 25936. (p. 659)
14—Cystid plate; Specimen 25958; ×4. (p. 667)
15—Orthoceracone cephalod; Specimen 25959. Slightly reduced. (p. 668)
16—Bellerophontid gastropod; Specimen 25935; ×2. (p. 667)
17, 18—*Basiliella trumpyi* Harrington & Kay; Pygidia. *17*, Holotype 25944; *18*, External mold; Paratype 25945, slightly enlarged. (p. 665)
19, 20—*Symphysurus metaensis* Harrington & Kay, n. sp. *19*, Cephalon fragment; Holotype 25941. *20*, pygidium; external mold; Paratype 25956; ×2½. (p. 663)
21—*Megalaspis* sp. cf. *M. planilimbata* Angelin. Pygidium, external mold; 25943; ×2. (p. 665)
22—*Tropidopyge stenorhachis* Harrington & Kay, n. sp., Pygidium. Holotype 25942; ×2. (p. 663)

two-thirds marked by eight straight and well defined rings, but segmentation becomes obscure in the posterior third; axis continued to rear by narrow keel which does not reach posterior margin.

Pleural lobes marked by 12 strong costae, gently bent at distal ends, separated by deep pleural grooves; surface of costae flat, devoid of interpleural furrows; anterior costae moderately oblique, obliquity rapidly increasing backwards. Concave border rather wide and flat, not sharply defined from pleural lobes.

Length of holotype pygidium, 20 mm., width, 24 mm.

Length of paratype pygidium, 27 mm., width, 36 mm.

Remarks.—Although the pygidia bear a superficial resemblance to some species of *Megalaspis*, notably *M. extenuata* Dalman (Schmidt, 1906, p. 49, pl. 8, figures 1 and 3), their different type of pleural segmentation and ill-defined concave border precludes reference to the genus. Our specimens are best considered as belonging to *Basiliella* Kobayashi, a genus heretofore known from the Chazyan and Bolarian of North America, the Upper Tremadocian of Argentina and the Chikunsan of South Chosen.

The Colombian pygidia are very similar to those of *Basiliella kawasakii* Kobayashi from South Chosen (Kobayashi, 1934, p. 470, pl. 35, figures 4 and 5 and pl. 37, figure 10). The number and courses of the pleural costae are quite alike, as well as the width and ill-defined character of the concave border; but our species is distinguished by its narrower axial lobe which, furthermore, is practically smooth along its distal end. Although Kobayashi stated in his diagnosis of the genus that it has a "semicircular" pygidium, *Basiliella kawasakii* shows a parabolic tail almost one-fourth wider than long.

Locality.—Za-81, Southern Central Macarena (Upper Tremadocian). Two pygidia.

Holotype.—25944; *paratype*: 25945.

Genus NIOBELLA Reed
NIOBELLA (?) sp.
Plate 96, figure 23

1943. *Asaphellus* (?) sp. KAY, in Trumpy, p. 1287.

A single pygidium from Caño Guapayito may belong to the genus *Niobella* Reed or *Niobe* Angelin, which are indistinguishable by this feature alone.

This is a small pygidium, almost semicircular in outline and almost twice as wide as long; border well developed, concave; axis conical and rounded behind, just reaching the border, showing faint traces of three segments along its anterior half; posterior half practically smooth.

Pleural lobes marked by four faint pleurae. Articular facet strong, sharply bent backwards and outwards at its distal half.

Length of the pygidium 5 mm., width 8 mm.

Remarks.—This pygidium may be compared with that of *Niobella aurora* Westergård from the *Peltura* zone of the Upper Cambrian of Sweden (Westergård, 1939, p. 7, pl. 2, figure 1 and pl. 3) and with that of the genotype, *Niobella homfrayi* Salter from the Tremadocian of Wales (Salter, 1864, p. 143, pl. 20, figures 3, 7 and 12 especially). The last named species usually shows obsolete segmentation at the distal half of the axis and four or five pleurae, and the axis does not encroach over the concave border as in *N. aurora*.

The reference to *Niobella*, however, cannot be definite as it is practically impossible to distinguish *Niobella* from *Niobe* on the pygidia alone.

Locality.—Za-81, Caño Guapayito, Central Macarena, Lower Tremadocian. Pygidium.

Illustrated specimen.—25946.

Genus EHMANIA Resser
EHMANIA AKANTHOPHORA Harrington & Kay, n. sp.
Plate 96, figures 1–5

Cranidium small, moderately convex longitudinally and strongly so transversely. Glabella long, gently tapering forward, evenly rounded in front; width about two-thirds its length; quite convex, rising over fixed cheeks; smooth, with indistinct glabellar furrows in internal molds. Dorsal furrows deep; occipital furrow straight; occipital ring widened at middle, produced into strong posteriorly directed spine, as long as breadth of ring. Brim convex, slightly depressed in front of glabella, width about one-fourth length of glabella. Margin upturned, narrowly convex, gently curved. Fixed cheeks rather broad, somewhat convex; eyes medium sized, slightly nearer posterior than anterior margin, distant from glabella somewhat more than half its width; palpebral lobe one-third as long as glabella, rising

sharply from short palpebral furrow; ocular ridges not evident; posterior limbs of fixed cheeks triangular and strongly depressed marginally. Anterior branches of facial sutures very slightly divergent in front of palpebral lobes, gently curved at marginal furrow, curving sharply medially along margin. Pygidium unknown.

Cranidium with occipital spine, about 4 mm. long, 3.5 mm. wide.

Remarks.—The species resembles many species of *Ehmania*, but differs most obviously in bearing a strong occipital spine. *Ehmania ? unispinata* Deiss (1939, p. 83) was assigned questionably to the genus because of its bearing a blunter spine, and the writers originally assigned the two species to a new genus. Dr. Christina Lochman Balk writes that the occipital spine has no generic significance and we are becoming doubtful that it has specific value (letter of October 9, 1950); hence the species is placed in the genus *Ehmania* on the assumption that the presence of spines is intrageneric. Dr. Balk points out that species of *Bythicheilus* Resser are similar, but that the genus is synonymous.

Locality.—R-356, Quebrada Agua Bonita on the Uribe Trail, from loose boulders (Middle Cambrian). Several cranidia, somewhat disorted.

Holotype.—U. 25950; *paratypes* 25947–49.

EHMANIA ? AMPHIBOLA Harrington & Kay, n. sp.
Plate 96, figures 6–9

1943. *Plethopeltis* (?) aff. *Bathyurus orbignianus* KAY, in Trumpy, p. 1289.

Cranidium small, convex both longitudinally and transversely. Glabella conical, rounded in front, raised over the fixed cheeks, well defined by deep dorsal furrows, longer than wide and practically smooth. One specimen has retained very faint traces of one pair of lateral glabellar furrows. Occipital ring slightly widened at middle, occipital furrow wide and comparatively shallow.

Brim wide and convex, width about one-fourth length of glabella (without occipital ring). Border upturned, about half as wide as the brim, narrowing rapidly laterally. Fixed cheeks raised. Palpebral lobes unknown but apparently of medium size, placed somewhat to rear of midpoint of cranidium and distant from glabella somewhat less than half glabellar width. Ocular ridges distinct, raised and oblique backward.

Anterior branches of facial suture moderately divergent in front of the eyes, then broadly curving inwards cutting the border and marginal to the center.

Length of cranidium, 5 mm., width, 4.8 mm.

Remarks.—The cranidia seem to agree with Resser's diagnosis of *Ehmania* and may be compared with such species as *Ehmania smithi* (Walcott) Resser from Alabama (Walcott, 1911, p. 92, pl. 17, fig. 3 and Resser, 1938, p. 75, pl. 8, figures 61 and 62), which, according to Walcott, has "glabella without traces of transverse furrows except a short, slight indentation indicating a posterior pair of furrows."

The generic reference is provisional, as the palpebral lobes are unknown. Moreover, there is such distortion in the rock that it is barely possible that the specimens are but unspined variants of *E. akanthophora* n. sp.

Locality.—R-356, Quebrada Agua Bonita on the Uribe trail, Eastern Cordillera, loose boulders, Middle Cambrian. Several cranidia.

Holotype.—25951; *paratypes*, 25952–53.

INDETERMINED FOSSILS

Cystoidea unidentified (Plate 97, figure 14).

A single detached hexagonal plate, rather badly preserved and fragmentary, probably belongs to an indeterminable cystoid genus. It was found associated with *Megalaspis* cfr. *planilimbata* at Locality Hu-612 in southern Central Macarena; 25958, illustrated.

Bellerophontid (Plate 97, figure 16).

A single distorted and fragmentary internal cast of a gastropod belongs to a narrowly phaneromphalus genus which, furthermore, seems to show a rather marked lateral and posterior flaring of the aperture. This feature, however, may be exaggerated by distortion. Faint traces of either a wide carina or a selenizone are indistinctly observed. The specimen was found in the *Megalaspis* sp. cfr. *M. planilimbata* beds of Locality Hu-612, southern Central Macarena; 25935, illustrated.

Oxydiscus (*?*) sp. (Plate 96, figure 17).

A small, planispiral gastropod doubtfully referred to *Oxydiscus* is associated with

Kainella macarenae n. sp. from Za-81, the Upper Tremadocian of South-central Macarena; 25957, illustrated.

Orthoceracone (Plate 97, figure 15).

A badly preserved external cast of an indeterminable orthoceracone is some 38 mm. long and 14 mm. wide. No trace of the external sculpture, if it possessed any, has been preserved. *Megalaspis* beds of southern Central Macarena; 25959, illustrated.

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NEW CARBONIFEROUS CRINOIDS

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ABSTRACT—Four new genera are proposed as *Paianocrinus*, n. gen., with *P. durus*, n. sp. the genotype; *Bronaughocrinus*, n. gen., with *B. figuratus*, n. sp. the genotype; *Mantikosocrinus*, n. gen., with *M. castus*, n. sp., the genotype; and *Heliosocrinus*, n. gen., with *H. aftonensis*, n. sp. the genotype. Other Chester crinoids described are *Paianocrinus aptus*, n. sp., *Tholocrinus foveatus*, n. sp., and *Agassizocrinus patulus*, n. sp. From the Virgil series of the Pennsylvanian, *Stellarocrinus virgilensis*, n. sp. is figured for comparison with *H. aftonensis*.

INTRODUCTION

THIS study is primarily based on crinoids found in late Chester formations of eastern Oklahoma. It has already been noted by several authors that Chester crinoids belong almost entirely to the Inadunata, though an occasional Camerata appears and several Flexibilia are known. This condition extends into the Pennsylvanian. The presently described crinoids are more comparable to those of Pennsylvanian age than heretofore known.

The author wishes to acknowledge the excellent materials contributed to this study by Mrs. Melba Strimple, Mr. Claude Bronaugh and Mr. Allen Graffham.

SYSTEMATIC DESCRIPTIONS

Genus PAIANOCRINUS Strimple, n. gen.

Genotype.—Paianocrinus durus, n. sp.

Generic diagnosis.—Dorsal cup is flat, cone-shaped, with upflared IBB. There are five IBB, five BB, five RR and three anal plates within the dorsal cup. The anal plates are in normal (primitive) arrangement. Articulating facets fill the entire width of RR and there is a slight gaping along the sutures.

The arms are uniserial to mildly cuneiform, branch once with the first primibrachials and once again in all rays. A third and fourth bifurcation takes place in the outer rays of some rami. All brachials are moderately low, wide and have well rounded exteriors. The axillary primibrachials are rather robust and in the genotype they are extended as stout spines.

Tegmen is composed of circlets of six small hexagonal plates and takes the form of an elongate tube. The column is small and round.

Geologic and geographic distribution.—This genus is known only from the Pitkin limestone, Chester, Mississippian of Oklahoma.

Relationships.—The form of the cup in this genus is somewhat comparable to that of *Hydreionocrinus* de Koninck (1858). However, the latter genus has biserial arms which bifurcate numerous times. *Eratocrinus* Kirk (1938) is probably more closely related but it has a more erect dorsal cup, with radial plates well removed from infrabasal circlet and the arms branch more often.

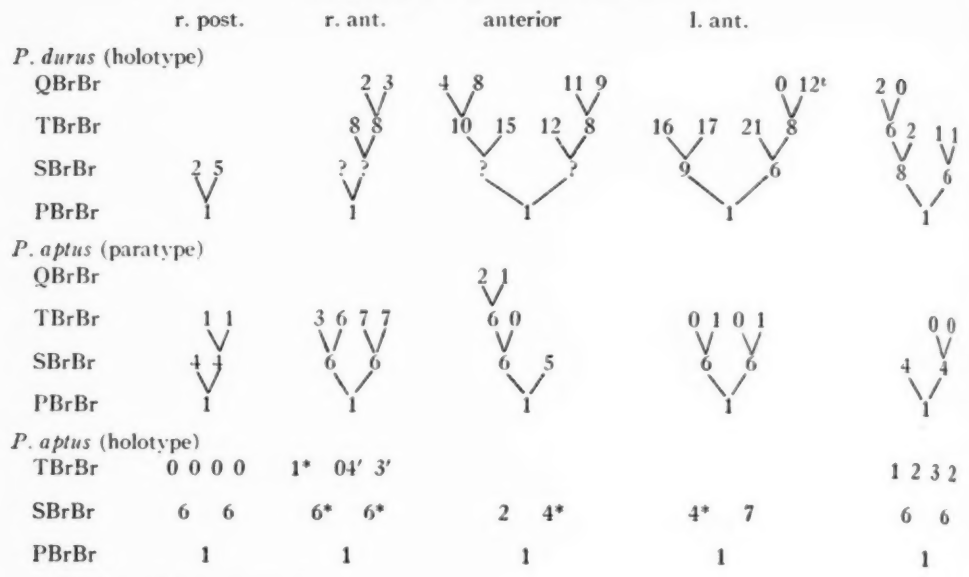
Some species of the Pennsylvanian genus *Laudonocrinus* Moore and Plummer (1940) have calices very similar to those of *Paianocrinus*. The first primibrachials of *Laudonocrinus* are known to be exterded as stout spines and it is anticipated by this author that the arms will be found similar to those of the present genus if and when they are discovered.

PAIANOCRINUS DURUS Strimple, n. sp.
Plate 99, figures 6–8

Description.—Dorsal cup is flat, cone-shaped. Five IBB rise directly from the columnar attachment and are visible in side view of the cup. Five BB are of moderate size and have short lateral sides. RR are five wide plates. In the post. IR, anal X rests directly on the horizontal truncated distal extremity of post. B, RA is elongate, resting on both post. and r. post. BB and RX rests evenly on the upper surface of RA.

All arms are pinnular and branch on the axillary first primibrachials, which plates

Analysis of arm structure for *Paianocrinus*.



* Distal portion regenerated.
' Entirely regenerated
t Termination.

are protruded as stout subhorizontal spines. A second bifurcation takes place in all observed rami, and a third and fourth branching occurs in the outer rays of some arms. The nonaxillary brachials are wide plates with well rounded exteriors. The arms are uniserial or slightly cuneiform. Pinnules are borne by alternating brachials.

Proximal columnals are round, thin segments. All plates of the crown are decidedly granular appearing under slight magnification. The tegmen is unknown.

Measurements

	Holotype mm.
Height of dorsal cup	3.6
Maximum width of dorsal cup	12.0
Length of l. ant. B	2.8
Width of l. ant. B	3.3
Average length of suture between BB	1.4
Length of l. ant. R	3.0
Width of l. ant. R	6.7
Average length of suture between RR	2.7
Diameter of proximal columnal	1.8

Remarks.—This species is closely related to *P. aptus* from which it differs in the more erratic bifurcation of the arms and presence of spinose axillary first primibrachials.

Occurrence and horizon.—Upper Pitkin limestone, Chester, Upper Mississippian; approximately 7 miles southeast of Braggs, Oklahoma.

Holotype.—Collected by Claude Bronaugh. To be deposited in the U. S. National Museum.

PAIANOCRINUS APTUS Strimple, n. sp.
Plate 99, figures 3–5

Description.—Dorsal cup is flat, cone-shaped. IBB are five and rise evenly from the columnar attachment. BB are five small plates with short lateral sides. Five RR are wide plates. Post. IR is composed of three plates, anal X, RA and RX, in normal arrangement.

Arms branch once on the axillary primibrachials in all rays. A second bifurcation takes place with the fourth to sixth secundibrachial in all rami. A third branching has been observed in some outer rays. Except for the mildly tumid axillary brachials, arm plates are quadrangular shaped with well rounded exteriors. In general the arms may be termed uniserial with a tendency toward cuneiformity.

The entire crown is weakly granular appearing under magnification. The column is

very small, round and is pierced by a minute round axial canal.

Preservation and exposure of the tegmen is not adequate for comprehensive observation; however, there appears to be an elongate tube composed of circlets of about six hexagonal plates, with radiating ridges which cross the sutures.

Measurements

	Holotype mm.
Width of dorsal cup	7.8
Height of dorsal cup	2.4
Length of l. ant B	2.0
Width of l. ant. B	2.1
Average length of suture between BB	0.7
Length of l. ant. R	1.8
Width of l. ant. R	3.9
Length of sutures between RR	1.4
Diameter of proximal columnal	0.9

Remarks.—There may be some question as to the maturity or lack of maturity of *P. aplus*, so it is mentioned here that first primibrachials of immature specimens are usually very elongate, which is not the case in this species. Among Pennsylvanian forms, it has also been noticed by the author, very young specimens have thin, elongate spines on the PBrBr when those plates are protruded as spines in maturity. These plates are only mildly tumid in the present species but are strongly spinose in *P. durus*.

Occurrence and horizon.—Upper Pitkin limestone, Chester, Mississippian; approximately 7 miles southeast of Braggs, Oklahoma.

Types.—Holotype and paratype were collected by Claude Bronaugh. To be deposited in the U. S. National Museum.

Genus BRONAUGHOCRINUS Strimple, n. gen.

Genotype.—*Bronaughocrinus figuratus*, n. sp.

Generic diagnosis.—Crown is rather short, constricted in area about the first primibrachials. Dorsal cup is very wide and has a pronounced basal invagination. IBB five, small, BB five, large, RR five, large, and three or two anal plates in the post. IR. Arms are broad, biserial, bifurcate once with the axillary first primibrachial. Column is very small, round and pierced by minute axial canal. Tegmen is unknown.

Geologic and geographic distribution.—Pitkin limestone, Chester, Mississippian; Morrow series and Missouri series, Pennsylvanian of Oklahoma.

Relationships.—This genus has certain characteristics which might be indicative of relationship to either *Phanocrinus* Kirk (1937) or *Eupachycrinus* Meek and Worthen (1886), as restricted by Kirk. There is considerable evidence indicating that *Phanocrinus* evolved to Pennsylvanian forms also having uniserial arms. Of course a divergent trend might have developed biserial arms. However, it seems more likely that a branch of the more robust *Eupachycrinus* may have evolved to *Bronaughocrinus* through reduction in the number of arms.

Plates of the posterior interradius are most distinctive in the present form. They follow the "Developmental Trend B" as propounded in my study of developmental trends found in specimens of *Phanocrinus* (1948). Anal X retains contact with post. B but RA has become the dominant anal plate and has nearly eliminated RX as an element of the cup.

Ethelocrinus oklahomensis Moore and Plummer (1937) is referred to *Bronaughocrinus* both on the basis of the cup structure and on the structure of the arms as illustrated by Strimple (1940). *Parulocrinus marquisi* Moore and Plummer (1940), of the Missouri series, is also referred to this genus.

BRONAUGHOCRINUS FIGURATUS Strimple, n. sp.

Plate 99, figures 9–11

Description.—Crown is broad, short and is constricted in the area about the first primibrachials. Dorsal cup is broad and low, attaining its greatest width just above mid-height. There is a broad, pronounced basal concavity, and the sutures are not impressed. IBB are five very small plates, almost entirely covered by the proximal columnal. BB are five large plates with proximal half in the basal invagination. Proximal extremities of BB are very narrow, and the median portion of each plate is mildly depressed as a shallow groove. RR are five large plates. R. post. R may have only four sides when the RX is entirely eliminated from the cup by the upward extension of RA. Other RR are pentagonal. Post. IR is broad and may be composed of two or three anal plates within the dorsal cup. Anal X rests on the horizontal truncated upper extremity of

post. B, is rather elongate and smaller than RA. The RA (radianal) is large, pentagonal, in firm contact with r. post. and post. BB, and sometimes reaches the most distal extremity of the cup. RX rests on RA but is often entirely out of the cup due to the unusual length attained by RA.

There are ten broad, biserial arms having flattened exteriors. First bifurcation takes place on the low, broad, axillary first primibrachials. After the constriction of the primibrachial area, the arms widen to just below midheight and do not taper appreciably until the distal extremities are approached. Pinnules are small and rather elongate.

The column is quite small, round and is pierced by a minute axial canal. Columnals are thin and are alternatingly expanded. The tegmen is unknown. There is no evidence of ornamentation.

Measurements

	Holotype mm.	Small paratype mm.	Large paratype mm.
Height of crown	45.0	38.0	56.0*
Height of dorsal cup	10.4	9.8	10.6
Maximum width of dorsal cup	29.0	25.7	32.7
Diameter of proximal columnals	3.0	2.8	3.5
Length of l. post. B	14.1	—	—
Width of l. post. B	10.3	9.1	12.0
Length of suture between BB	9.2	—	—
Length of l. ant. R	11.4	7.0	11.7
Width of l. ant. R	15.7	12.2	17.1
Length of suture between RR	5.5	4.5	5.9
Length of RA	10.5	8.6	10.0
Width of RA	7.1	5.9	7.0
Length of l. ant. PBr	3.6	3.5	3.7
Width of l. ant. PBr	14.1	11.7	14.8
Height of basal concavity	3.2	—	—

* Approximate.

Remarks.—*Phanocrinus cooksoni* Laudon (1941) is somewhat comparable to *B. figuratus* in having a low broad cup, broad basal invagination, three anal plates in the posterior interradius and ten short arms. However, the former species has uniserial arms and the anal plates are in normal arrangement.

Two species from Pennsylvanian strata have been referred to the genus. They are *B. oklahomensis* (Moore and Plummer) and *B. marquisa* (Moore and Plummer). The former differs from *B. figuratus* in having nodular ornamentation and pronounced protrusion of the arms at midlength. The latter differs in having strongly impressed sutures and more advanced arrangement of anal plates

Several species of *Delocrinus* are known which have arms comparable to those of *B. figuratus*, but in that genus there is only one anal plate retained within the calyx.

Occurrence and horizon.—Upper Pitkin limestone, Chester, Mississippian; approximately 7 miles southeast of Braggs, Oklahoma.

Types.—Holotype collected by Melba Strimple. Measured paratypes collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Genus AGASSIZOCRINUS Owen & Shumard, 1852

AGASSIZOCRINUS PATULUS Strimple, n. sp.

Plate 98, figures 9–10; plate 99, figure 12

Description.—Dorsal cup is elongate and flares slightly at its distal extremity. Five IBB are fused into a high cone. Sutures between IBB are dim, but since they are visible it is apparent that complete anchylosis has not been attained. Of the five BB, three are six sided, post. and r. post. BB are seven

EXPLANATION OF PLATE 98

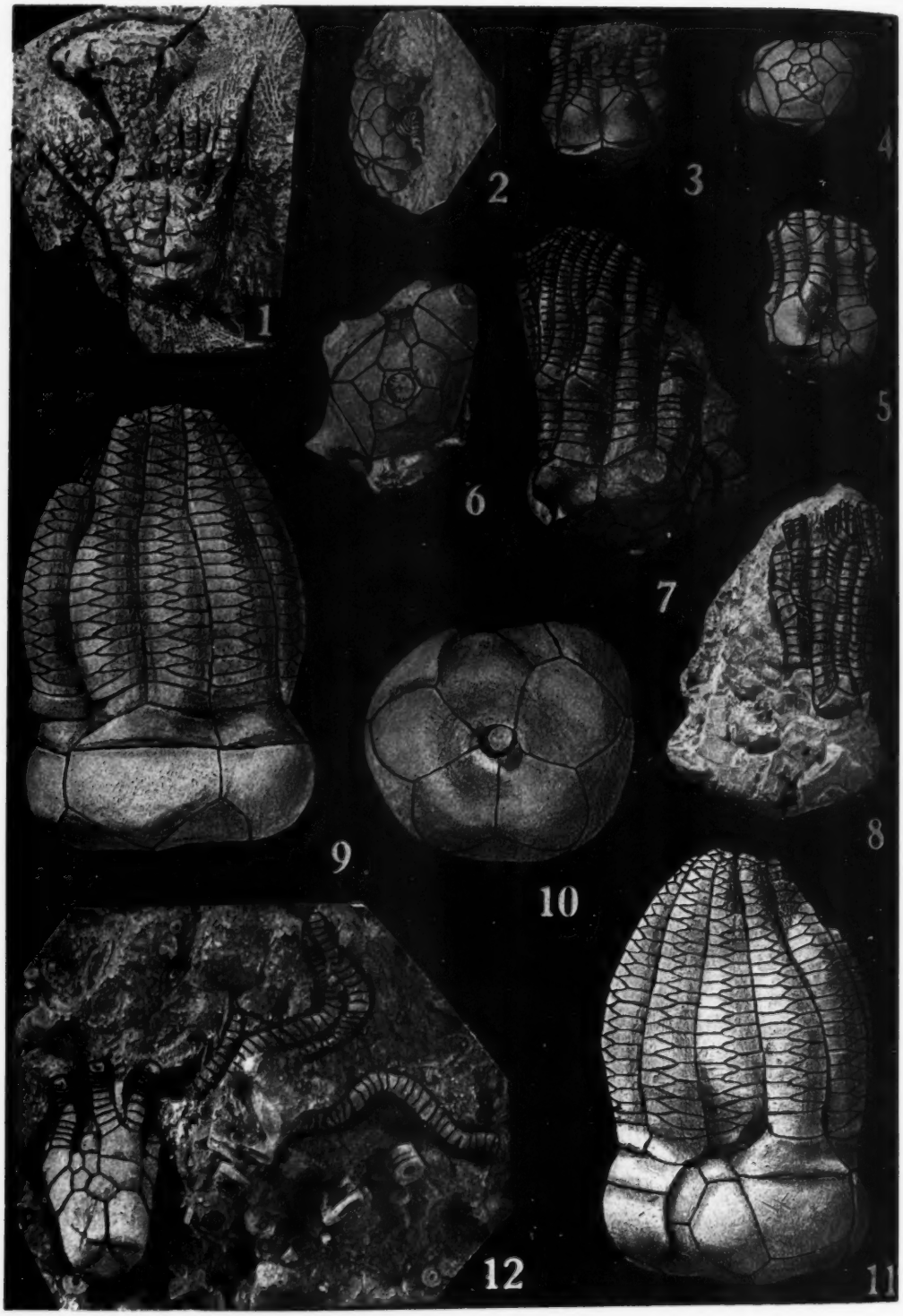
FIGS. *1, 2, 5, 6*—*Stellarocrinus virgilensis* Strimple, n. sp., ×1.8. *1, 2*, arms of a paratype. *5, 6*, summit and basal views of the holotype. (p. 675)

3, 4, 7, 8—*Heliosocrinus aftonensis* Strimple, n. sp., ×1.8. *3, 4*, anterior and posterior views of a paratype. *7*, oblique view of the holotype. *8*, basal view of a paratype. (p. 676)

9–10—*Agassizocrinus patulus* Strimple, n. sp., ×1.4. *9, 10*, left anterior and posterior views of the holotype. (p. 672)

11–13—*Mantikosocrinus castus* Strimple, n. sp., ×1.4. *11, 12, 13*, anterior, basal and posterior views of the holotype. (p. 674)

Strimple, Carboniferous Crinoidea



Strimple, Carboniferous Crinoidea

sided. Five RR are pentagonal and have slightly greater width than length. Articulating facets fill the distal faces of RR. Four anal plates occupy the post. IR. RA is the larger and rests on the post. and r. post. BB. RX is directly above the RA and anal X to the left. Anal X rests directly on the truncated upper extremity of post. B and supports an "extra" plate above. The distal half of the extra anal plate extends into the interbrachial area. There is a hard smooth surface to the entire cup.

Ten arms are preserved. They are narrow, long, uniserial and branch with the large axillary first primibrachials. Pinnules are present but are poorly preserved.

No evidence or vestige of a column has been disclosed in any of the more than a dozen specimens observed. The tegmen is unknown.

Measurements

	Holotype mm.	Figured paratype mm.
Height of IBB cone	5.9	—
Length of IBB cone	7.6	—
Maximum width of IBB cone	8.2	—
Height of dorsal cup	14.0	—
Maximum width of cup	10.6	10.8
Length of r. post. B	6.8	6.4
Width of r. post. B	6.9	5.7
Length of suture between BB	4.3	3.6
Length of r. ant. R	3.1	3.5
Width of r. ant. R	5.6	4.3
Length of suture between RR	2.9	2.6
Length of r. post. PBr	4.0	3.6
Width of r. post. PBr	5.6	5.0

Remarks.—This small colony of *Agassizocrinus patulus* was discovered in the spring of 1950. The zone is about 3 inches thick with some specimens partially imbedded in the dense matrix, and others entirely imbedded. Exposed specimens are on the under side of the layer. The matrix is black, but weathers grey.

Other described species of *Agassizocrinus* have a tendency to curve inward as the uppermost extremity of the cup is approached, whereas, in *A. patulus* there is an outward flare at this point. *Paragassizocrinus tarri* (Strimple) (1939) has a somewhat comparable appearing shape to the cup, but there is only one anal plate in the post. IR.

Occurrence and horizon.—A few feet above the lowermost massive limestone member of the Pitkin limestone, Chester, Mississippian; road cut in the west side of Braggs Mountain, about 3 miles southeast of Ft. Gibson, Oklahoma.

Types.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Genus MANTIKOSOCRINUS Strimple, n. gen.

Genotype.—*Mantikosocrinus castus*, n. sp.

Generic diagnosis.—Dorsal cup evenly rounded, with mildly convex base. IBB five, BB five, RR five and three anal plates in the post. IR. The anal plates are in normal (primitive) arrangement. Arms are ten, broad, uniserial, pinnular and bifurcating with the first primibrachials. Ventral sac unknown. Column is round.

Geologic and geographic distribution.—This genus is only known from the upper Fayetteville formation, Chester, Mississippian of Oklahoma.

Relationships.—The genus appears to be closely related to *Cromyocrinus* Trautschold (1867) and *Dicromyocrinus* Jaekel (1918). There are only five uniserial arms in the former genus which distinguishes it from the ten uniserial arms of *Mantikosocrinus*. The

EXPLANATION OF PLATE 99

FIGS. *1–2*—*Tholocrinus foveatus* Strimple, n. sp., ×1.4. *1, 2*, left postero-anterior and basal views of the holotype. (p. 674)

3–5—*Paianocrinus aptus* Strimple, n. sp., ×1.8. *3, 4, 5*, anterior, basal and posterior views of the holotype. (p. 670)

6–8—*Paianocrinus durus* Strimple, n. sp., ×1.8. *6, 7, 8*, basal, left posterior and anterior views of the holotype. (p. 669)

9–11—*Bronaughocrinus figuratus* Strimple, n. sp., ×1.4. *9, 10, 11*, anterior, basal and posterior views of the holotype. (p. 671)

12—*Agassizocrinus patulus* Strimple, n. sp., ×1.4. *12*, posterior view of a paratype embedded in matrix. (p. 672)

latter genus has a mild basal concavity, with subhorizontal IBB plates, deeply impressed sutures, slightly more advanced post. IR and decidely cuneiform or biserial arms.

MANTIKOSOCRINUS CASTUS Strimple, n. sp.
Plate 98, figures 11–13

Description.—Dorsal cup bowl-shaped with mildly convex base. Five IBB are small with distal portions curving slightly upward. Five BB are large, mildly bulbous appearing. Five RR are of moderate size, pentagonal and bulbous. Three anal plates, in normal arrangement, occupy the post. IR; anal X in broad contact with post. B; RA to the right, in contact with r. post. and post. BB and supporting RX above. The surface of the cup is devoid of ornamentation except for slight ridges marking the edges of the cup plates. Minute depressions are present at the distal extremities of BB, the proximal apices of RR and mark the angles of the plates in the post. IR.

There are ten robust uniserial arms. First primibrachials are approximately twice as wide as high and are axillary. Secundibrachials are broad low plates. Pinnules are rather long and delicate.

Proximal columnals are round, small and are penetrated by a round, minute axial canal. The tegmen has not been observed.

Measurements

	Holotype mm.
Maximum width of dorsal cup	14.5
Height of dorsal cup	5.1
Width of proximal columnal	2.8
Width of IBB circlet	4.7
Length of r. ant. B	4.1
Width of r. ant. B	6.6
Length of suture between BB	1.9
Length of r. ant. R	5.0
Width of r. ant. R	8.2
Length of suture between RR	2.6
Length of r. ant. PBr	3.5
Width of r. ant. PBr	7.0

Remarks.—*Mantikosocrinus castus* is closely comparable to *Cromyocrinus simplex* Trautschold (1867) which species, however, has only five uniserial arms, decidedly upflared IBB and cup plates which are not tumid. *Dicromyocrinus geminatus* (Trautschold) (1867), has tumid cup plates but the IBB are subhorizontal and repose in a basal concavity, and the ten arms are cuneiform.

Occurrence and horizon.—The holotype, and one other specimen which is in the collection of Allen Graffham, were found within inches of each other in a yellow clay just below the massive limestone which marks the base of the Pitkin limestone, Fayetteville formation, Chester, Mississippian; road cut in the west side of Braggs Mountain about 3 miles southeast of Ft. Gibson, Oklahoma.

Holotype.—Collected by Allen Graffham. To be deposited in the U. S. National Museum.

Genus THOLOCRINUS Kirk, 1939
THOLOCRINUS FOVEATUS Strimple, n. sp.
Plate 99, figures 1–2

Description.—Dorsal cup low bowl-shaped, mildly constricted in the distal extremity and possessing a small restricted basal concavity. Five IBB are almost entirely covered by the proximal columnal; five BB are rather tumid; five RR are slightly bulbous, distal extremities curve inward and arm articulating facets are directed outwardly at a low angle; three anal plates in normal (primitive) arrangement. A small round depression is found at the angles of all plates in the BB and RR circlets.

The arms are slender, uniserial and pinnular. First primibrachials are axillary and each develops a sharp spine near the distal extremity. A second bifurcation occurs in both rami with about the seventh secundibrachials. Another bifurcation has been noted on or about the sixth tertibrachial in some rays. All axillary brachials are spinose.

Tegmen plates are small and have prominent cross ridges, and slits along the lateral edges. The tube is long and slender, terminating with a mushroom-like top composed of large, flat, spine-like plates. The tegminal "umbrella" is above the distal extremities of the arms.

Column is rather large and tapers noticeably a short distance from the cup. Columnals are alternatingly expanded and are of moderate thickness.

Measurements

	Holotype mm.
Height of crown	26.7
Height of dorsal cup	3.6
Width of dorsal cup	9.2
Width of proximal columnals	2.1
Width of anal tube (at midlength)	4.2

Remarks.—The broad flat base, with a small basal depression for the column and IBB plates, distinguishes this from other species referred to *Tholocrinus*. Other species have comparatively broad basal invagination. Another distinctive character of *T. foveatus* is the presence of small pits at the apices of the plates of the BB and RR circlets. Such dimple-like depressions are typical of the Pennsylvanian genus *Endelocrinus* Moore and Plummer (1940), which form has only ten arms and one anal plate in the post. IR. and could hardly be related to the species under consideration.

Occurrence and horizon.—A fine grained, dense limestone layer which weathers a buff grey, about 4 to 5 inches thick, near the middle of the upper half of the Pitkin limestone, Chester, Mississippian; road cut in the west side of Braggs Mountain, about 3 miles southeast of Ft. Gibson, Oklahoma.

Types.—Collected by H. L. Strimple. To be deposited in the U. S. National Museum.

Genus STELLAROCRINUS Strimple, 1940

STELLAROCRINUS VIRGILENSIS Strimple, n. sp.

Plate 98, figures 1, 2, 5, 6

Description.—Dorsal cup is shallow, with depressed basal area. IBB are confined to the bottom of the basal invagination and extend slightly beyond the proximal columnal. BB curve out of the basal concavity and two or three nodes are present in the median portion of each plate. These nodes become more or less confluent in some instances and form a broken ridge-like development which is met by more pronounced ridges on the adjoining RR. Articulating facets of the RR are large and have pronounced intermuscular notches. RA is pentagonal and rests directly on the truncated upper extremity of post. B. Anal X and RX are supported evenly by RA. Anal X is slightly larger. Fine granules on most of the cup plates are apparent under slight magnification.

The arms are thick, biserial and branch once with the axillary first primibrachials. Another bifurcation takes place with the ninth to twelfth secundibrachials. The axillary secundibrachials are triangular pieces which are enclosed by the meeting of outer edges of the tertibrachials with the last nonaxillary secundibrachials. Each PBrBr has a small sharp node in midsection. Axillary SBrBr are protruded as elongate spines. Most SBrBr develop one small node and, under magnification, have borders of fine granules. Most TBrBR do not develop nodes but in the outer series one brachial will often protrude as an elongate spine. This later development has been observed to take place with the seventh to eleventh TBr. Subsequent TBrBr appear to be normal. Outer surfaces of the arms are only mildly convex.

Anal tube is large and is composed of circlets of six plates. Each tube plate is marked by a sharp ridge at midheight and has approximately five pore slits in each lateral side. These pores are matched by similar slits in adjacent tube plates. Fine granular ornamentation is apparent under weak magnification.

Measurements

	Holotype mm.
Diameter of column	3.7
Approximate width of dorsal cup	16.8
Height of cup to outer ligamental furrow	2.6

Remarks.—Stellarocrinus virgilensis is most readily distinguished from other described species by the strong spine-like protuberance of some brachials, and the distinctive ornamentation of the cup.

Occurrence and horizon.—All figured specimens were found in an area about 3 feet square in the Nelagony formation, about 35 feet below the Wildhorse limestone member, Virgil series, Upper Pennsylvanian; NW ¼ sec. 21, T. 22 N., R. 10 E., Osage County, about 15 miles west of Skiatook, Oklahoma.

Genus HELIOSOCRINUS Strimple, n. gen.

Genotype.—Heliosocrinus aftonensis, n. sp.

Generic diagnosis.—Dorsal cup low, base concave, sharp ridges pass from one cup plate to the adjoining. IBB five, BB five, RR five and three anal plates within the post. IR. Arm articulating facets fill the distal faces of RR and are directed outward. Anal plates are in normal (primitive) arrangement. First bifurcation of the arms takes place with the second primibrachials in all rays. A second branching is known to occur in the outer rays of some arms. Se-

cundibrachials, and tertibrachials are slightly wedge-shaped, carry pinnules, and form cuneiform arms. Column is pentagonal to pentalobate.

Geologic and geographic distribution.—The genus is only known from the Fayetteville formation, Chester, Mississippian of Oklahoma.

Relationships. — *Stellarocrinus* Strimple (1940) is apparently the only closely related genus. It has a round column, RA has moved to a dominant position and the arms branch with the first primibrachial.

HELIOSOCRINUS AFTONENSIS
Strimple, n. sp.
Plate 98, figures 3, 4, 7, 8

Description.—In the dorsal cup there are five IBB confined to the basal concavity and entirely covered by the large pentalobate proximal columnals; five large BB curve out of the basal invaginated area and are extended as thin elongate spines, which are directed slightly downward; sharp ridges on the BB connect with similar ridges on adjoining RR and are prominent on plates of the post. IR; five RR have outwardly directed arm articulating facets, which do not fill the distal portions of the plates; three anal plates are anal X, resting on post. B., RA to the right below and in contact with r. post. and post. BB, and RX following directly above RA.

There are more than ten cuneiform arms. First primibrachials are low, thick, nonaxillary plates. Second primibrachials are slightly elongate, are often protruded as sharp spines and are axillary. Normal secundibrachials are spinose and pinnular bearing.

Anal tube is known to be elongate and spinose. The column is composed of rather thin strongly pentalobate plates which are pierced by a round axial canal. Crenulations are deeply impressed and follow the outline of the columnals.

Measurements

	Holotype mm.	Figured paratype mm.
Maximum width of column	4.5	4.2
Width of dorsal cup at summit	12.0	11.3*
Height of cup at ligamental furrow	3.5	3.8

* Average.

Remarks.—*Heliosocrinus aftonensis* is more comparable to *Stellarocrinus distinctus* Strimple (1940) than to any other described species. The latter has a round stem, less extended basal plates and arm branching takes place with first primibrachials as compared to the pentagonal stem of *H. aftonensis* and arm branching with the second PBrBr.

Types.—Holotype collected by Melba Strimple. Figured paratype collected by Claude Bronaugh. To be deposited in the U. S. National Museum.

Occurrence and Horizon.—Fayetteville formation, Chester group, Upper Mississippian; about 5 miles southwest of Afton, Craig County, Oklahoma.

REFERENCES

All references are listed in BASSLER, R. S. and MOODEY, MARGARET W., 1943, Index of Paleozoic pelmatozoan echinoderms: Geol. Soc. America, Special Paper 45, with the following exception;

STRIMPLE, HARRELL L., 1948, Notes on *Phanocrinus* from the Fayetteville formation of northeastern Oklahoma: Jour. Paleontology, vol. 22, pp. 490–493, text-figs. 1–8, pl. 77.

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ATRYPA IN WESTERN AUSTRALIA

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ABSTRACT—From an extensive collection of Devonian fossils from the Kimberley Division, Western Australia, an aggregate of specimens of *Atrypa* were selected for study. The variation met with in this genus during the course of the study is described, the need stressed for a quantitative approach to such variable forms, and also certain problems raised in the treatment of this genus are discussed.

Two new species are described and three new subspecies. It is concluded that the Western Australian species of *Atrypa* have as close affinities with the European forms as those of intermediate areas.

INTRODUCTION

THE collection upon which this study is based is part of a large series of Devonian fossils secured by Dr. C. Teichert in the course of a reconnaissance through the Devonian areas of the Kimberley Division in the Northeast of Western Australia. For an excellent preliminary report on the Devonian of this area the reader is referred to Teichert, 1943.

Specimens of *Atrypa* have been found throughout Middle Devonian strata in this area and are particularly abundant in the higher Middle Devonian limestone horizons to which they give the name—the *Atrypa* limestone.

Since *Atrypa* formed such a significant minor percentage of the collection it was thought that the delineation and identification of the species present would be of value when the detailed stratigraphy of the Devonian is attempted, since species of *Atrypa* seem to possess greater stratigraphic value than that generally assigned to them (Alexander, 1949; Fenton and Fenton, 1930, 1931; Hall, 1894, Stainbrook, 1938).

There has been little systematic work done on species of this genus from Western Australia. Foord in 1890 recorded the presence of *A. reticularis* but beyond saying that the presence of this "easily recognised species" indicated the presence of Devonian rocks in the Kimberley District did not enter into a detailed description of his specimens. Hosking in 1933 examined a set of Devonian fossils from the same area as the present collection and amongst them identified and described species of *Atrypa*—*A. aspera*, *A.* cf. *aspera*, *A. desquamata*, and *A. reticularis*. The material dealt with by this author was limited and not well preserved and with the advent of much more *Atrypa* material forming the present collection it was found necessary to revise and extend her identifications.

The collection consisted of about 250 specimens, most of them in a poor state of preservation, obtained either from a limestone matrix or as weathered-out specimens. As a result the surface features of most specimens are worn or partially absent, so that considerable caution had to be exercised in taking measurements. A few were autoclaved from massive limestone samples. Oxalic acid was used with partial success to clean specimens covered with argillaceous material.

About 20 of the weathered specimens showed the recrystallised brachial spires. Even these varied greatly in the plan and structure of these elements, an observation in keeping with that of Alexander (1949, p. 211), in her investigation of the English *Atrypa reticularis*. No internal studies were made beyond the casual inspection referred to, as a few preliminary sections revealed little. The structures were heavily recrystallised, so much so that in some instances they were indistinguishable from the coarsely crystalline calcitic filling present in all specimens.

The specimens were collected at more or less haphazard points over a wide area. This, together with our as yet meagre knowledge of the detailed stratigraphy of the area precluded any attempt at correlation.

VARIATION IN *Atrypa*

The range of variation in the Western Australian species of *Atrypa* is as great as that which has rendered the delineation of species of this genus such a problem in other areas.

The following almost plaintive remark was made by Whidborne when faced by the variable English forms, ". . . while the differences are so great that it is almost impossible to imagine them all to be the same species, the connecting links are such that it is almost equally impossible to regard them as distinct." This remark is just as applicable to those of the Western Australian Devonian.

This problem of variation renders the delineation of species by qualitative means a most difficult task. As regards *Atrypa*, different workers have taken different attitudes when delineating synchronous species of the genus. Some have erected specific units on the more or less hazardous evidence of minor morphologic differences, others on the grounds of stratigraphic value, yet others have been content to draw attention to what they consider variant groups within the broad (many would say, too broad) framework of already recognised species.

The collection at first sight divides itself into three assemblages, roughly corresponding to the three most common species of the genus in Europe—*Atrypa aspera* Schlotheim, *A. desquamata*, Sowerby, and *A. reticularis* (Linnaeus). Of these *A. aspera* and *A. reticularis* may be said to form the end points of an extended and variable line. Between them, and possessing characters in common with the above species, lies an assemblage consisting of some individuals which approach closely to either of the two end points, but which nevertheless as an assemblage is quite distinct. To this group the name *desquamata* is attached. It might be mentioned here that there are some specimens in the group referred to, *A. reticularis*, which are most representative of the European forms of *A. reticularis*. But if this group is considered as a whole it can be seen that there are significant points of difference between it and those forms described as typical *A. reticularis*.

The same general statement applies to the other two broad groups which at first sight one would assign to *A. desquamata* and *A. aspera* respectively. Are these points of difference sufficient to warrant specific status for each group? In attempting to answer this question several difficulties immediately make themselves apparent.

The first is that the status of each of these three, and other species, of *Atrypa* is hazy and ill defined. Original descriptions covered such a degree of latitude it is more than possible, and probable, that subsequent authors have included similar but separate species under the broad and sheltering framework of these original loose descriptions. Such errors of judgment are pardonable when one is dealing with such a variable genus as *Atrypa*.

The second is that one must consider the possibility that these errors of judgment are not errors at all. There is no real paradox here. Many of the early described species of *Atrypa* do seem to be long ranging in time and wide ranging in area. It is the prevailing tendency to view with suspicion such species but attempts to split them into numerous new species on the grounds of minute morphological differences or of locally restricted stratigraphic position are not very convincing. As long as the species concept in paleontology remains a purely personal and arbitarary notion, it is almost impossible to condemn outright either extreme—the one inclined to over-generalize, the other to over-'split'. As in most other contentious matters the safest course and the one closest to the truth is the via media. This course is the one the author has endeavoured to pursue.

A third difficulty is intimately linked with the problem of the species concept in paleontology. In such a variable genus as *Atrypa* where, as an example, two forms, recognisable by the most cautious as distinct species, are found to be connected by a series of individual specimens merging in likeness one with the other by minute gradations, the question arises where to fix the boundary. At what point does one species end, the other begin? This question is obviously unanswerable and is really quite facetious. The solution to this difficulty lies, it would seem, in adopting an attitude similar to that of Leach in his treatment of the Anthracomyas of the Basal *Similis-Pulchra* zone in Scotland (Leach, 1940). The follow-

ing quotation from that author explains this attitude—"In the systematic treatment of variable communities it is becoming increasingly obvious that in many cases a wider concept of species may be necessary. *Anthracomya salteri* is a particular case in which distinction is only possible by consideration of the community as a whole."

The adoption of such an attitude would probably assist towards the acceptance of new type concepts, and nomenclature as proposed by Newell (1947), Simpson, (1940), and others, concepts which provide for a better estimate of 'real' species than those previously used.

Hence in the systematic descriptions to follow, emphasis is placed on the specific group as a whole, and the variation in each group is described. In short the groups are described in terms of the populations it is considered they represent and not as individuals.

It was stated above that the qualitative recognition of synchronous species within this genus is most difficult. Quantitative methods would in all probability result in a more accurate delineation of the species of variants present, and indeed many paleontologists now recognise that a quantitative approach to the treatment of fossil faunas is rapidly becoming advisable (see Burma, 1948). For various reasons, however, a full quantitative treatment of the material was impossible. The best that could be attempted was to approach the problem from a restrained qualitative, and to a lesser degree, semi-quantitative aspect.

In any case quantitative methods are ineffectual in solving the important problem of determining whether a species of *Atrypa* under study is specificallv distinct from an already described species, for the obvious reason that no quantitative analyses of already described species have been made.

GENERAL DECRIPTION OF THE FAUNA

Most of the specimens examined were mature and young, only a few showing gerontic features. For comparison only mature specimens were used. Maturity was deduced from a study of the seasonal growth rings, as distinct from the more numerous recession rings due to temporary disturbances of growth. The seasonal rings, even on relatively poorly preserved specimens were distinguished from the temporary growth rings by their prominence, and by their spacing, which diminishes slowly in a regular way. A specimen was considered to be mature if the spacing of the seasonal growth rings was seen to have changed from this wider spacing to a new and finer scale indicating the advent of the reproductive function.

As stated above, the collection divides itself into three broad divisions, and on qualitative grounds, it seemed safe to assume the presence of at least three distinct species. As a check on this assumption it was decided to regard the whole fauna as one species, to take two of the most diagnostic external features of the genus, using specimens at approximately the same stage of maturity, plot one against the other, and discover if the resultant grouping, if any, indicated the possible validity of the three groups, and the existence of variant subgroups.

The characters chosen were:

(1) The attitude of the beak to the general plane of commissure of the valves.
(2) The relative convexity of the two valves.

Of these two the inclination of the beak appears to be far less variable than the relative convexity of the valves, and is thus of greater diagnostic value. Values in (1) can be expressed accurately only by the angle θ, where θ is the angle of inclination of the beak to the plane of the commissure—as shown in fig. 1. Thus the angle θ measures approximately 90° for a beak described as 'erect' (Thompson, 1927). Accurate measurement of θ is, however, well-nigh impossible. The terms, *inclined*, *sub-inclined*, *erect*, *sub-erect*, *straight*, expressing approximate values of θ, were therefore used (see Thompson, 1927, p. 80). Similar reasons necessitated the use of the terms *dorsi-convex*, *sub-dorsi-convex*, *dorsi-biconvex*, and *dorsi-biconvex-weak*, and *biconvex*,—swollen and flat, for expressing the relative convexity of the valves. Terms relative to convexity are those used by McEwan (1939).

Graphical expression of these two characters one against the other, gave results indicated in fig. 1. The grouping noted in the figure serves as an indication only, of possible groups existing in the collection.

As an indication of the possible validity

of the three main groupings shown in the previous graph, a triangular graph showing the relative proportions, expressed as percentages, of the width, depth and length for each specimen of the groups was drawn. The measurement of each of these characters

As the investigation proceeded, however, this tentative identification had to be modified considerably, so that ultimately five groups were recognised. Each group, distinct to varying degrees from the other four, is sufficiently well defined, on the whole, to be

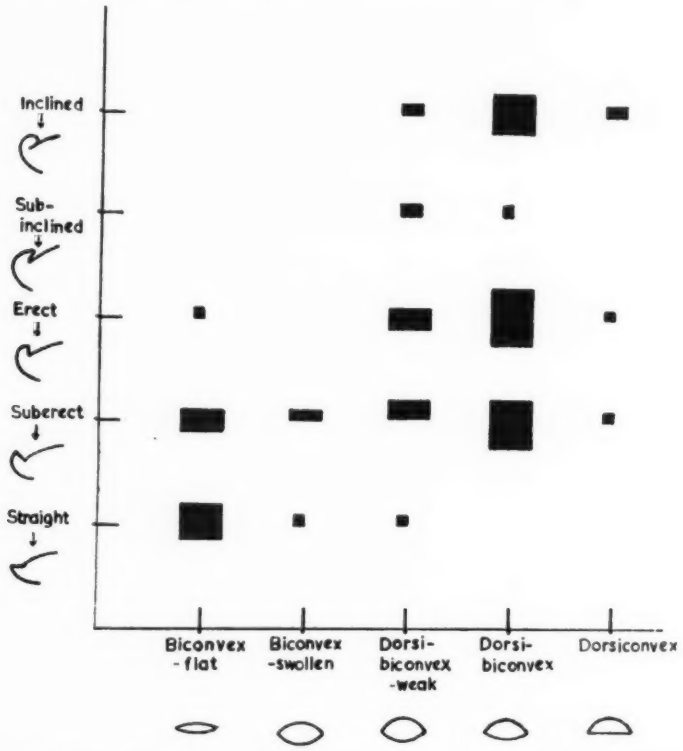


FIG. 1—Graph with relative incurvature of the umbo plotted against relative convexity of the valves, showing the resultant grouping for a large sample of specimens at the same growth state. Number of specimens indicated by the size of the rectangles. Bottom left group, *A. aspera prideri*. Top right group, *A. multimoda*. Middle group, *A. desquamata kimberleyensis*.

were added together and the percentage ratio of each determined for every specimen, with results illustrated by fig. 2.

The assumption then that there were at least three specific groups present, based on qualitative estimation, seems, if not proven, at least not disproven by the semi-quantitative methods described.

This semi-quantitative method of analysis served, not as a means of itself, of delineating any specific group present, having regard to the possible delusory nature of misapplied quantitative methods, but as a check on too exuberant qualitative analysis.

regarded as a separate species or subspecies.

Two of the groups are represented by less than seven specimens each and in the semi-quantitative analysis described, they were masked by the greatly superior numbers of mature specimens in the other three groups. But on qualitative grounds alone they are by far the most easily distinguishable. A sixth group has been described, but as it is suspected that the individuals comprising it are immature, it is not regarded as being definitely a new species and for the same reason it does not enter into the methods described above.

All of these species possess characters in common with the already described species of *Atrypa* from other countries. However, in view of the extreme range of variation exhibited, the doubtful validity of many species described, poor descriptions and illustrations, and similar difficulties, the principle was adopted that unless comparison of foreign species with local forms showed to a high degree of certainty that they were the same, then a new name should be given to the local form. Nevertheless the writer is not convinced of the general truth of an allied principle whereby geographic isolation is invariably taken as positive indication of a new species being present.

We see then that, from an initial determination by which the collection was considered to consist of three groups allied to the European *Atrypa reticularis*, *A. desquamata* and *A. aspera*, ultimate analysis showed five groups to be present, and possibly a sixth. Three of these, comprising over 90 percent of the specimens are considered subspecies of the three European forms. The remaining two are considered to be new species.

Locality numbers mentioned in the systematic descriptions are those of Teichert, 1949.

SYSTEMATIC DESCRIPTIONS

Order TELOTREMATA Beecher

Superfamily SPIRIFERACEA Waagen

Family ATRYPIDAE Gill

Genus ATRYPA Dalman 1828

ATRYPA RETICULARIS TEICHERTI Coleman, n. subsp.

Plate 100, figures 1–10.

Syntypes.–26273, a, b, c, d; 26893 a. Geology Department, University of W. A.

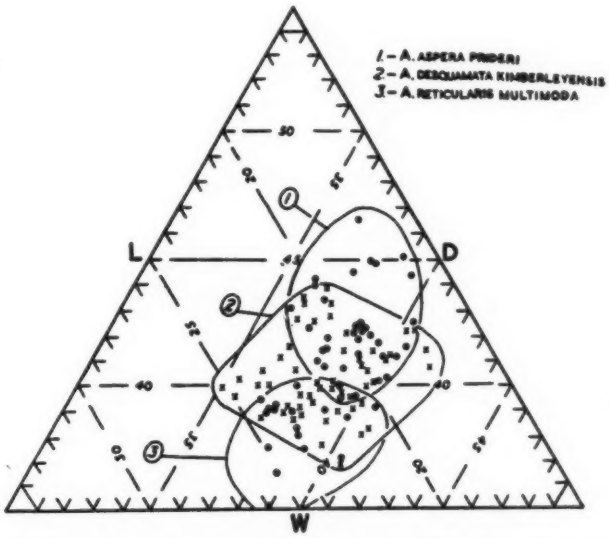


FIG. 2—Graph showing the relative proportions of the length, depth and width of the three most common species of *Atrypa* found in West Australia.

Shape and size.—Often slightly elongated, mostly orbicular; globose strongly dorsibiconvex; ventral margins often recurved. Greatest width at, or slightly below the hinge line. Greatest depth perpendicular to the line of greatest width. Dimensions of some typical specimens in mm.:

	26273a	26273c	26273d
Width	19	22.5	21
Depth	14.1	12.6	13
Length	21	22	21

No young forms of this group were in the collection.

Umbonal characteristics.—Beak small, pointed, strongly incurved. No foramen observed; no area; hinge line less than half of greatest width.

Ornamentation.—Costation medium, six–

seven lines in 5 mm. at the anterior margin of newly matured specimens. Increasing as in other forms at irregular intervals. Growth rings pronounced.

Sinus.—Pedicle valve sinus weak, but stronger in old specimens.

Remarks.—This subspecies is represented by only five specimens, but on qualitative grounds alone is most clearly defined. A few specimens in the group described as *A. multimoda* (see below), possess some characters in common with those comprising this new subspecies. Such relationship as does exist between these two groups will be discussed under the description of *A. multimoda*.

It seems quite distinct, for the most part, from previously described species of *Atrypa*, except where such forms share a common resemblance to *Atrypa reticularis*. It differs from the lectotype of this latter species in having a more convex pedicle ventral valve, the costation is finer, and whereas the ventral valve of the lectotype of *A. reticularis* is evenly convex, that of the local form is most convex immediately anterior to the umbonal region, thereafter flattening out.

Atrypa richthofeni Kayser (see Grabau, 1933, pl. 21, figs 7–11, pp. 186–190), has some similarities to the local subspecies. The umbo of the former, however, projects further posteriorly and is larger and broader than that of the latter which, in contradistinction, is small, pointed and projects only a small degree above the ventral valve.

Occurrence.—Fitzroy Basin, Kimberley Division, W. A. At the base of the *Atrypa* limestone, 2 miles east of No. 10 Bore, and at Brooking Gap. Localities No. 58, No. 1. (for these and other localities see Map, fig. 3).

Atrypa multimoda
Coleman, n. sp.
Plate 100, figures 11–18
Plate 101, figures 1–6

The specific name refers to the wide range of variation exhibited by this group.

Syntypes.—26553a,b,d. 26645b, c, d, f. Geology Department, University of W. A. Paratypes, 26550, c, j. 26464 j, Same repository.

Shape and size.—Generally more transverse than orbicular, broadest just below the hinge line, where the margins are sometimes produced into minor ears, margin of pedicle valve often recurved, particularly in geronic specimens. Mostly strongly dorsibiconvex, swollen. Dimensions, of some typical specimens (in mm.):

	26553b	26553a	26645d
Width	26.8	28.5	39.5
Depth	14.5	16.0	24.0
Length	25.8	28.0	37.0

Umbonal characteristics.—Beak small, narrow, incurved, mostly without an area, or if present it is very small, small apical foramen visible in a few specimens. Hinge line approximately half greatest width.

Ornamentation.—Costation medium, seven to eight lines per 5 mm. at first mature stage, sometimes coarser, increasing occasionally by bifurcation and intercalation. Growth rings pronounced.

Sinus.—Pedicle valve sinus mostly medium, rarely broad and weak.

Young specimens of this group are generally swollen biconvex to slightly dorsibiconvex, with beak erect to slightly incurved, and with fine to medium costation, the breadth at the hinge line being relatively less than in mature specimems.

Remarks.—The most characteristic feature of this group is the extreme range in variation exhibited by its members. Some specimens are practically indistinguishable from the Devonian European *A. reticularis*. Others approach closely *A. desquamata*. Indeed it is possible to find odd specimens which are mirror images for any one of a dozen described species from other areas. For this reason no direct comparison between local and foreign species is undertaken. It is only as a group that this species can be considered to possess any individuality, and thus individual specimens may be hard to place.

The following characteristics of this species are, however, fairly constant:

(1) the general transverseness of the shell.
(2) the formation of minor ears at the extremes of the posterior margin.
(3) the swollen, bulbous character of the shell.
(4) the absence of an area, or if present, the area is of very small extent.

As regards local forms, *A. multimoda* has closest affinities with *A. desquamata kimber-*

leyensis n. subsp. (see below), secondly to *A. reticularis teicherti*. It resembles the former in sometimes possessing a small area and in general shape, and the latter in that some specimens of *multimoda* are globose and possess an incurved beak—which, however, is never so strongly incurved as in specimens of *A. reticularis teicherti*. It is constantly larger at maturity than either of these two forms and this criterion in conjunction with the four characteristics mentioned above render it quite distinctive.

Occurrence.—(see Map)

Fitzroy Basin, Kimberley Division, W. A. Occurs abundantly in the upper Middle Devonian (*Atrypa* limestone) at the following localities—North end of Munyu Gap, Rough Range; near No. 10 Bore, Long's Well Area; just west of Gap Creek Gap area, S. E. Rough Range. Localities No. 31, 32, 51, 52, 53, 54, 57, 58.

ATRYPA DESQUAMATA KIMBERLEYENSIS
Coleman, n. subsp.
Plate 101, figures 7–19

Syntypes.—26247a, 26553b, l; 26550 c. Geology Department, University of W. A. Paratypes. 26553f, n, j. 26464a; 26247 d; Same repository.

Shape and size.—More transverse than orbicular, sometimes subquadrate, slightly dorsi-biconvex to medium dorsi-biconvex. Not globose. Greatest width just anterior to the hinge line in the majority of specimens. Greatest depth at right angles to, and slightly anterior to the line of greatest width. Dimensions of some typical specimens (in mm.):

	26553f	26553b	26247a
Width	24	28	27.5
Depth	12.5	12.5	14.0
Length	24.5	26.2	27

The young forms of this community are flat, oval to transverse, biconvex, with a pronounced beak which varies from erect to straight and reclined, with a large area. The costation is medium to rather fine.

Umbonal characteristics.—Beak large, wide, angular, suberect to erect, with a small exposed foramen, very nearly apical. Always with an area, better preserved specimens showing triangular deltidial plates. Umbonal ridges prominent.

Ornamentation.—Costation medium to fine, from five–seven lines per 5 mm. at maturity. Growth rings prominent.

Sinus.—Sinus of pedicle valve weak.

Remarks.—The greatest number of individual specimens in the collection belong to this group. It is fairly uniform in its characteristics and seems incapable of subdivision. Description and figures of *A. desquamata* by early workers agree very well with local forms. The latter, however, do not possess to any degree the median sinus in the dorsal valve mentioned by Whidborne (1893, p. 117, see also Hosking, 1933, p. 72). The degree of convexity exhibited by the local form seems higher than the European *A. desquamata*. This species has been subdivided into many varieties (Nalivkin, Grabau, Tien et al.), and isolated specimens of the Western Australian form appear to be very similar to some of these. But these local specimens are so obviously members of the one group that comparison between any one of these and some particular variety previously described would be a departure from the principle of describing the species in terms of the group and not of one or more individuals.

A. desquamata kimberleyensis is a rather variable form. Specimens at either extreme of the range of variation, to use again a linear concept purely in an illustrative sense, have close affinities with *A. multimoda*, and *A. aspera prideri* n. subsp. respectively. Immature specimens of *A. desquamata kimberleyensis* in particular, can be distinguished by cursory examination from mature specimens of *A. aspera prideri* only by the finer costation of the former subspecies. The more convex forms of *A. desquamata kimberleyensis* can be distinguished from specimens of *A. multimoda* by the more angular beak and larger area of the former.

Occurrence.—Fitzroy Basin, Kimberley Division, Western Australia. Abundant throughout the *Atrypa* limestone of the upper Middle Devonian at the following localities—about three miles SE. of Long Hole Bore; the north end of Minyu Gap, Rough Range; around and about No. 10 Bore; Long Well Area; Mt. Pierre Gorge; at reef on Old Bohemia Homestead road, about four miles west of Old Bohemia Home-

stead and at Old Bohemia Road Gap about five miles west of Old Bohemia Homestead. Also in *Amphipora* limestone, lower Middle Devonian, at a locality east of Napier Downs, South of Findlay's Trig. 12. Localities No. 9, 31, 32, 51, 52, 53, 54, 57, 60, 61, 62.

ATRYPA ASPERA PRIDERI
Coleman, n. subsp.
Plate 102, figures 1–17

Syntypes.—26261a, c, 26126 l, 26255b. Geology Department, University of W. A. Paratypes. 26126k; 26255a, c, same repository.

Shape and size.—Rarely exceeding 20 mm. in greatest dimensions at maturity. Transverse mostly flat, biconvex, occasionally with recurved ventral margins. Dimensions of four typical specimens (in mm.):

	26261a	26126l	26255b	26261c
Width	19.2	17.5	19	23.5
Depth	7	7.5	7.3	10.5
Length	17	15.5	16	19.5

Young forms of this group are distinguished by their extreme flatness, the extreme coarseness of the costation, the enormous size of the umbo in comparison with the rest of the shell, and by the very large subapical foramen.

Umbonal characteristics.—Beak sharp pointed, wide, angular, never incurved but generally produced parallel to the plane of commissure of the valves, sometimes suberect. Possessing an area variable in size but none of the specimens show the deltidial plates so characteristic of *A. desquamata*, possibly because of the poor preservation of most of the specimens.

Ornamentation.—Costation, always coarse rounded, four–five in 5 mm. at the first mature stage, occasionally increasing by bifurcation and intercalation, although less frequently than is the case with any of the other groups. Growth rings are prominent, often giving a nodular or reticulate appearance to the surface, and showing a tendency to form lamellae, and very occasionally, spines.

Sinus.—Pedicle valve sinus absent, or if present, broad and weak.

Remarks.—The coarse costation, general flatness, transverseness, and the produced beak found in members of this subspecies, render it quite distinct. Young forms of *A. desquamata kimberleyensis* might be confused with mature specimens of this subspecies, but the costation of the former is never as coarse as the latter.

A. aspera prideri differs from the classic descriptions of *A. aspera* by early authors in the following features:

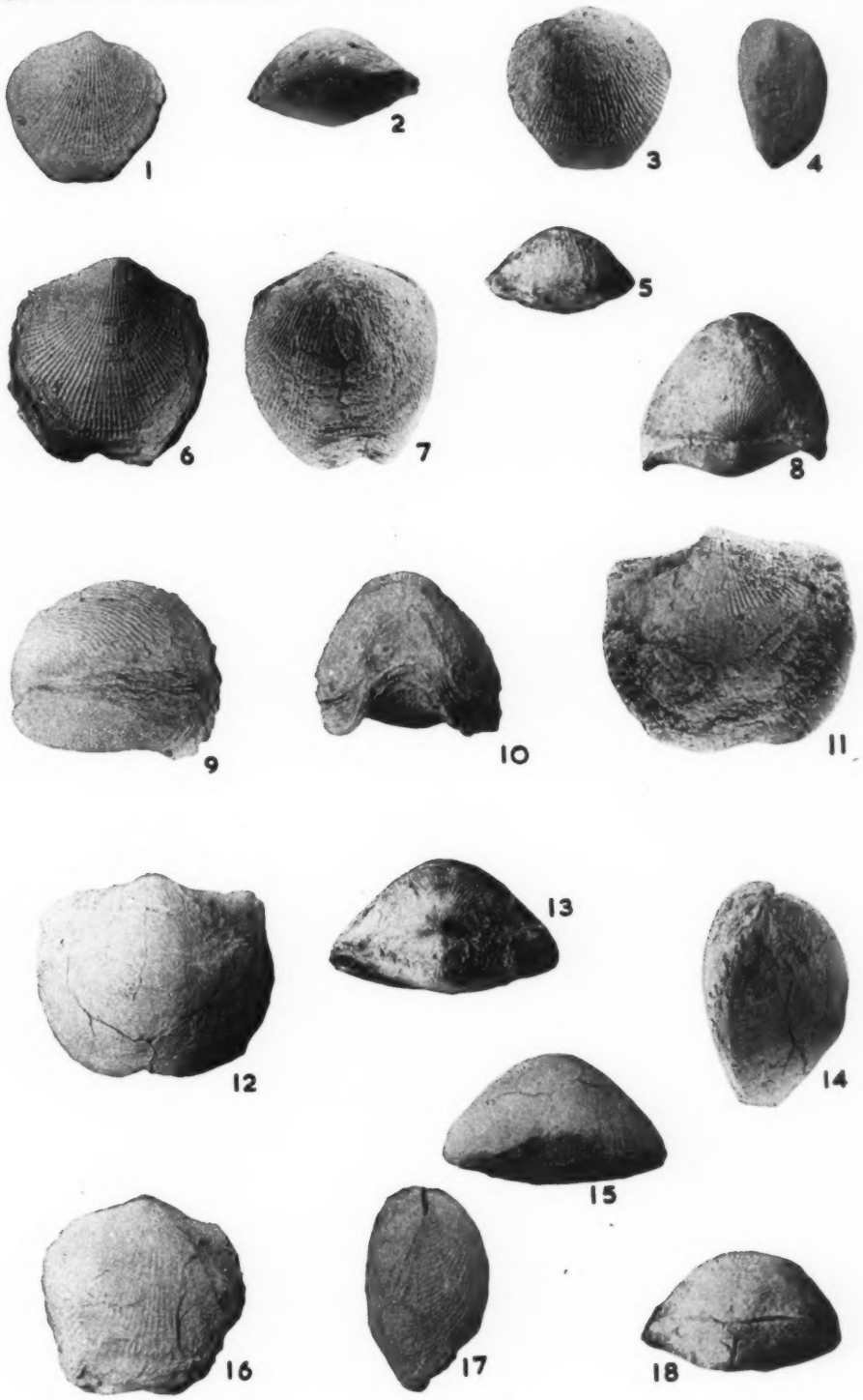
(1) The beak of the local form does not incurve to any great degree.
(2) The costae do increase by intercalation and bifurcation (see Whidborne, 1893, p. 116).
(3) The degree of convexity is usually much less.

It has strong resemblances to *A. bodini* Mansuy (Mansuy, 1912, p. 75 pl. 13, fig. 10 a–e; Grabau, 1933, p. 190, pl. 15, figs. 12–14; pl. 21, figs. 12 a–e, pl. 22, figs. 1, 2, 3, 4, a–e) but differs as much from the latter in the character of the umbo as it does from the European *A. aspera.* In this feature *A. bodini* occupies an intermediate position, with its erect and pointed beak to the European form and *A. aspera prideri*, which have incurved, and suberect to flat-lying beaks, respectively. It also is very like V. Kelus' variety, *A. reticularis* var. *orientalis* from the Devonian of Volhynien (Poland) but our subspecies has a larger area, the beak is not so incurved and the costae are somewhat finer. *Atrypa tubaecostata* Paeckelmann, from the Upper Devonian of North Germany, is yet another European species very akin to *A. aspera*

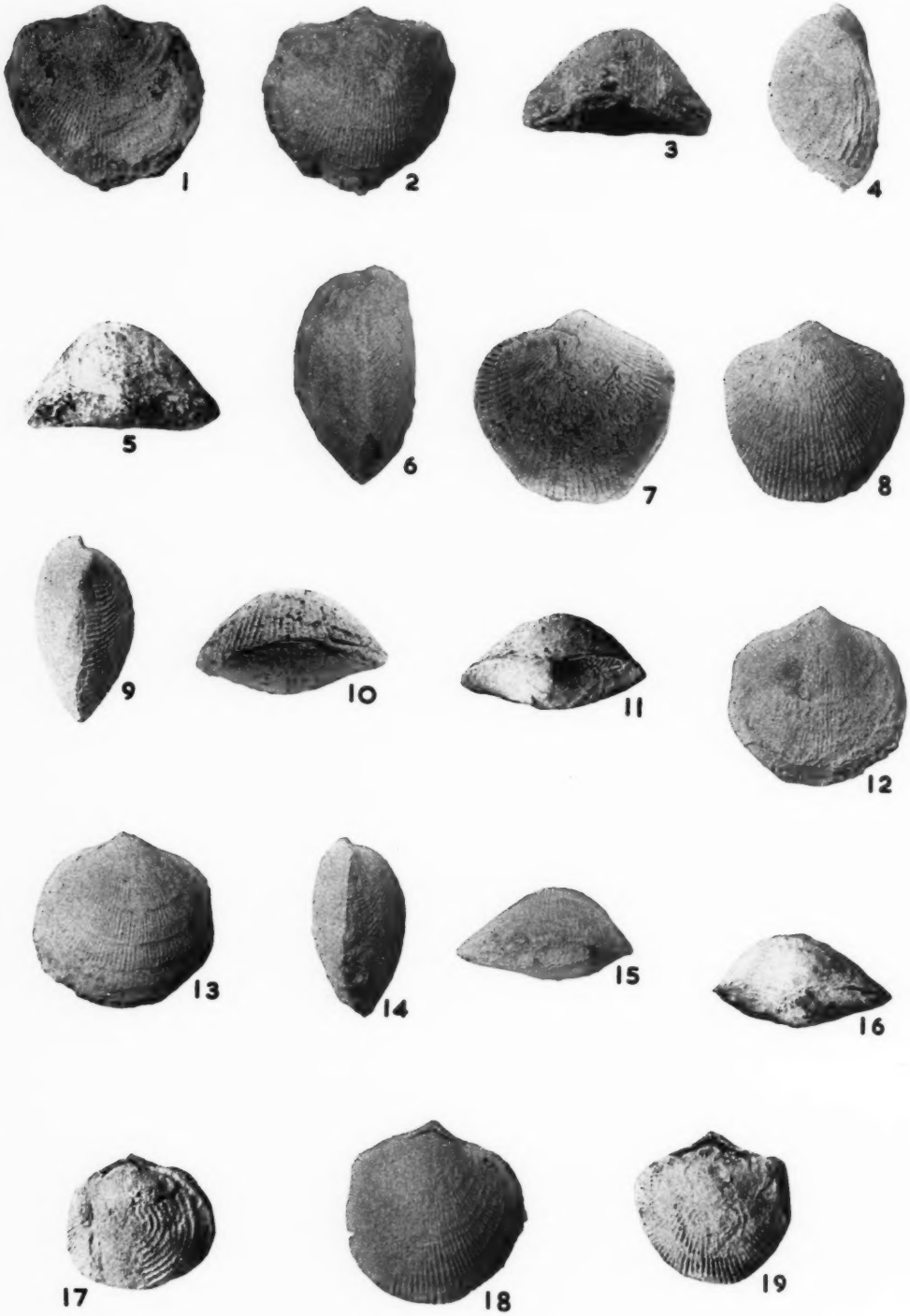
EXPLANATION OF PLATE 100

FIGS. *1–10*—*Atrypa reticularis teicherti* Coleman, n. subsp. *1–5*, ventral, posterior, dorsal, lateral and anterior views of syntype 26273c, U.W.A.; from base of *Atrypa* limestone 2 miles east of No. 10 Bore, Rough Range area, Kimberley Division, West Australia. *6–10*, ventral, dorsal, posterior, lateral, and anterior views of gerontic specimen, syntype 26893a, U.W.A. Same locality. (p. 681)

11–18—*Atrypa multimoda* Coleman, n. sp. *11–15*, ventral, dorsal, posterior, lateral, and anterior views of syntype 26645d, U.W.A. from north end of Minyu Gap, Rough Range area, Kimberley Division, West Australia. *Atrypa* limestone. *16–18*, dorsal, lateral and posterior views of syntype 26645f, U.W.A. Same locality. (p. 682)



Coleman, Australian *Atrypa*



Coleman, Australian *Atrypa*

prideri but it is more convex and on the whole very much larger than the local subspecies.

Occurrence.—Fitzroy River Basin, Kimberley District, Western Australia. Abundant in *Atrypa* limestone at the following localities: about three miles SE. of Long Hole Bore in limestone; the north end of Minyu Gap, Rough Range; in the vicinity of No. 10 Bore, Long's Well area; in reef on old Bohemia Homestead road about four miles west of old Bohemia Homestead. Localities Nos. 91, 31, 32, 51, 52, 53, 54, 57, 58, 60, Also from newly discovered Devonian in the North West Basin (see Teichert. 1949). Localities No. 11, 20, 29.

ATRYPA PARVA
Coleman, n. sp.
Plate 102, figures 18–29

Syntypes.—26294a, b, c, d. 26641a. Geology Department, University of W. A. Paratypes. 26292b, d. 26293, a,b,d,e. Same repository.

Shape and size.—Generally transverse to quadrate, biconvex to dorsibiconvex, swollen, the brachial valve being uniformly convex, the ventral valve often showing a far less degree of convexity towards the anterior margin than in the umbonal region. Widest just below the hinge line which is very long. Rarely exceeds 17 mm. in greatest dimension. Dimensions of four typical specimens (in mm.):

	26294a	26294b	26294d	26294c
Width	16.2	20.2	15.2	16
Depth	8	9.8	7.8	7.5
Length	14.8	16.8	14.0	14

The young forms are distinguished by their long hinge line, dorsibiconvexity, sharp small umbo, transverse but frequently orbicular outline, and reticulate surface. They are usually less convex than more mature specimens.

Umbonal characteristics.—Beak small, very narrow, pointed, suberect, with a small foramen, subapical and abutting against the umbo of the dorsal valve. Very small area.

Ornamentation.—Costation medium, but variable, pronounced. Growth rings pronounced, giving the surface a reticulate appearance.

Sinus.—Ventral sinus broad and weak to medium.

Remarks.—This species bears some resemblance to *A. reticularis teicherti*, but is much smaller at maturity and constantly so, than any specimens of the latter species. Also the beak is persistently less incurved.

Atrypa parva differs markedly from *A. aspera prideri* in these features:

(1) Its shape is radically different, being swollen and rather strongly dorsibiconvex
(2) The umbonal characteristics are quite different—the umbo is small, narrow, erect and without an area.

None of the remaining local forms bear any resemblance to this species.

Atrypa concinna Lindemann from the Silurian of Sweden is the only species from other areas which bears comparison with our species. The resemblance is very strong, but *A. concinna* does not seem to possess any area whatsoever and the beak is more incurved.

Occurrence.—Fitzroy River Basin, Kimberley District, Western Australia. Higher part of *Atrypa* limestone, upper Middle Devonian, from low hill of yellow limestone 1½ miles SW. of Long's Well.

EXPLANATION OF PLATE 101

FIGS. *1–6*—*Atrypa multimoda* Coleman, n. sp. *1–5*, ventral, dorsal, anterior, lateral, and posterior views of syntype 26553a, U.W.A. from locality 2 miles ENE. of Gap Creek Gap, South-East Rough Range, Kimberley Division, West Australia. *Atrypa* limestone? Lateral view shows umbo much less incurved than is typical for the species. *6*, lateral view of another syntype, 26645b, surface outcrops at No. 10 Bore, same general locality, showing the more typical highly incurved umbo. (p. 682)

7–19—*Atrypa desquamata kimberleyensis* Coleman, n. subsp. *7–11*, ventral, dorsal, lateral, anterior, and posterior views of syntype 26247a, U.W.A. from surface outcrops, at No. 10 Bore Rough Range area, Kimberley Division, West Australia. Low Upper Devonian? *12–16*, ventral, dorsal, lateral, anterior, and posterior views of syntype 26553b, U.W.A. Same locality. *17*, weathered specimen showing the outline of the brachial spires, from near Long's Well, same general locality, *Atrypa* limestone. *18–19*, typical specimens showing the well defined area typical of this species; same locality as above syntype 26553b. (p. 683)

TABLE *1*—SUMMARY OF THE CHARACTERS OF THE WEST AUSTRALIAN SPECIES OF *Atrypa*

	A. multimoda	*A. reticularis teicherti*	*A. desquamata kimberleyensis*	*A. aspera prideri*	*A. parva*
AVERAGE WIDTH	21 mm.	30 mm.	28 mm.	19 mm.	17 mm.
AVERAGE DEPTH	13 mm.	17 mm.	14 mm.	8 mm.	8.5 mm.
AVERAGE LENGTH	21 mm.	27 mm.	27 mm.	17 mm.	15 mm.
SHAPE	Often slightly elongate but mostly orbicular. Globose. Strongly dorsibiconvex. Margin recurved.	More transverse than orbicular. Strongly dorsibiconvex. Swollen. Margin recurved.	More transverse than orbicular; often subquadrate. Medium dorsibiconvex to slightly dorsibiconvex.	Transverse, flat, biconvex to slightly dorsibiconvex.	Transverse to subquadrate biconvex to dorsibiconvex. Swollen. Margin recurved.
UMBONAL CHARACTERISTICS	Beak small pointed very incurved. Foramen never observable. No area. Hinge line $<\frac{1}{2}$ greatest width.	Beak small incurved. Hinge line approximately $\frac{1}{2}$ greatest width. Foramen often observable. Sometimes has very small area.	Beak large wide suberect to erect, with exposed foramen. A pronounced area with deltidial plates.	Beak pointed, wide angular, sub-erect to straight. Has a very large area.	Beak small narrow pointed, sub-erect. Showing small foramen. Very small area.
ORNAMENTATION	Costation medium to fine, 6–7 in 5 mm. at mature margin. Growth rings pronounced. Costae frequently dividing.	Costation medium, 5–6 in 5 mm. at mature margin. Growth rings pronounced.	Costation medium, 5–6 in 5 mm. at mature margin. Growth rings pronounced. Costae frequently dividing.	Costation coarse, average 4 in 5 mm. at mature margin. Dividing only rarely. Growth rings very prominent.	Medium but variable. Growth rings pro-. nounced. Reticulate surface. Costae frequently dividing.
SINUS	Mostly weak, occasionally medium.	Medium, rarely broad and weak.	Mostly weak.	Broad and weak.	Broad and weak to medium.

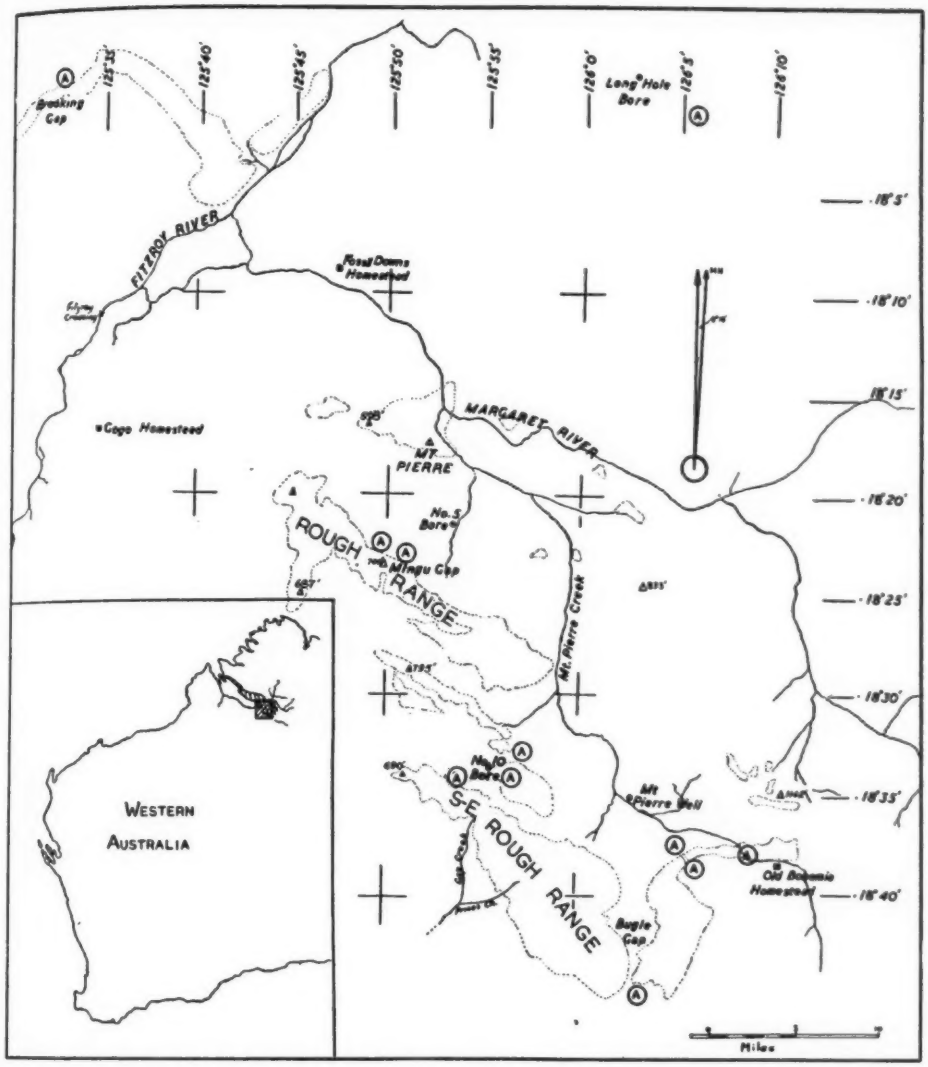


FIG. 3—Localities where species of *Atrypa* occur and which yielded abundant specimens used in this study are marked "A". The area figured is at the southeast end of the principal Devonian sedimentary area in West Australia (see inset).

ATRYPA n. sp.
Plate 102, figures 30–32

Material.—26116A a,b,c,d,p; 26117b; 26123 b, c. Geology Department, University of W. A.

Shape and size.—Mostly orbicular, but may be slightly transverse or subquadrate; glocose, biconvex to slightly dorsibiconvex. Ventral margins sometimes slightly recurved anterolaterally. Greatest width midway between posterior and anterior margins. Greatest depth at right angles to line of greatest width. Dimensions of some typical specimens (in mm.) :

	26117a	26116Ab	26116Ab
Width	21	21	22.5
Depth	13	11.8	13.5
Length	20	20	22.5

Umbonal characteristics.—Beak small, pointed but rapidly becoming broader an-

teriorly. Umbonal ridges prominent. Area triangular, narrow. No foramen or deltidial plates observed, possibly due to poor preservation. Beak not incurved but mostly nearly straight. Tip of beak lies well below hinge line. Hinge line short, half to a third of greatest width.

Ornamentation.—Ornamentation not well preserved. Costation appears to be rather fine from what can be seen. Growth rings not observable.

Sinus.—Pedicle valve sinus broad and weak.

Remarks.—Specimens of this possibly new species are all rather poorly preserved. In the absence of growth rings it is not possible to estimate whether or not any of the specimens are mature. The umbonal characteristics are reminiscent of immature forms of the other local species and since the specimens are all small it is possible that they are immature. This being so it was thought best not to confer a specific name to this group until further material comes to hand. It is suggested that they do represent a new species as they are unlike any of the young forms belonging to the other local species, and they do not seem to have any counterparts in the described species from other areas.

RELATIONSHIPS OF THE WEST AUSTRALIAN SPECIES OF *Atrypa*

The widespread occurrence of similar, possibly the same, species of *Atrypa*, and their persistence over comparatively long periods with but little change makes the task of determining the inter-relationships of the species of one particular area, with those of other areas, more difficult than is the case with many other fossil groups.

It seems that most of those who have met with this difficulty have found the solution in regarding geographic isolation as sufficient reason for the erection of new specific or varietal names. Hence in a study of the relevant literature one is met with a host of such names representing forms most of which, from a study of the figures at any rate, seem very little different from the few initial species recognised during the last century.

Species of *Atrypa* have been described from practically every locality where fossiliferous Devonian sediments occur.

As mentioned in the descriptions above, a study of the relevant literature reveals species which agree rather closely with odd specimens of the groups, *A. reticularis teicherti*, *A. multimoda*, *A. desquamata kimberleyensis* and *A. aspera prideri*. Closer affinities between foreign and the local species would probably be more evident were the validity of many of the previously described species not open to question and, in the unavoidable absence of actual specimens, were the descriptions and illustrations of these forms of a higher

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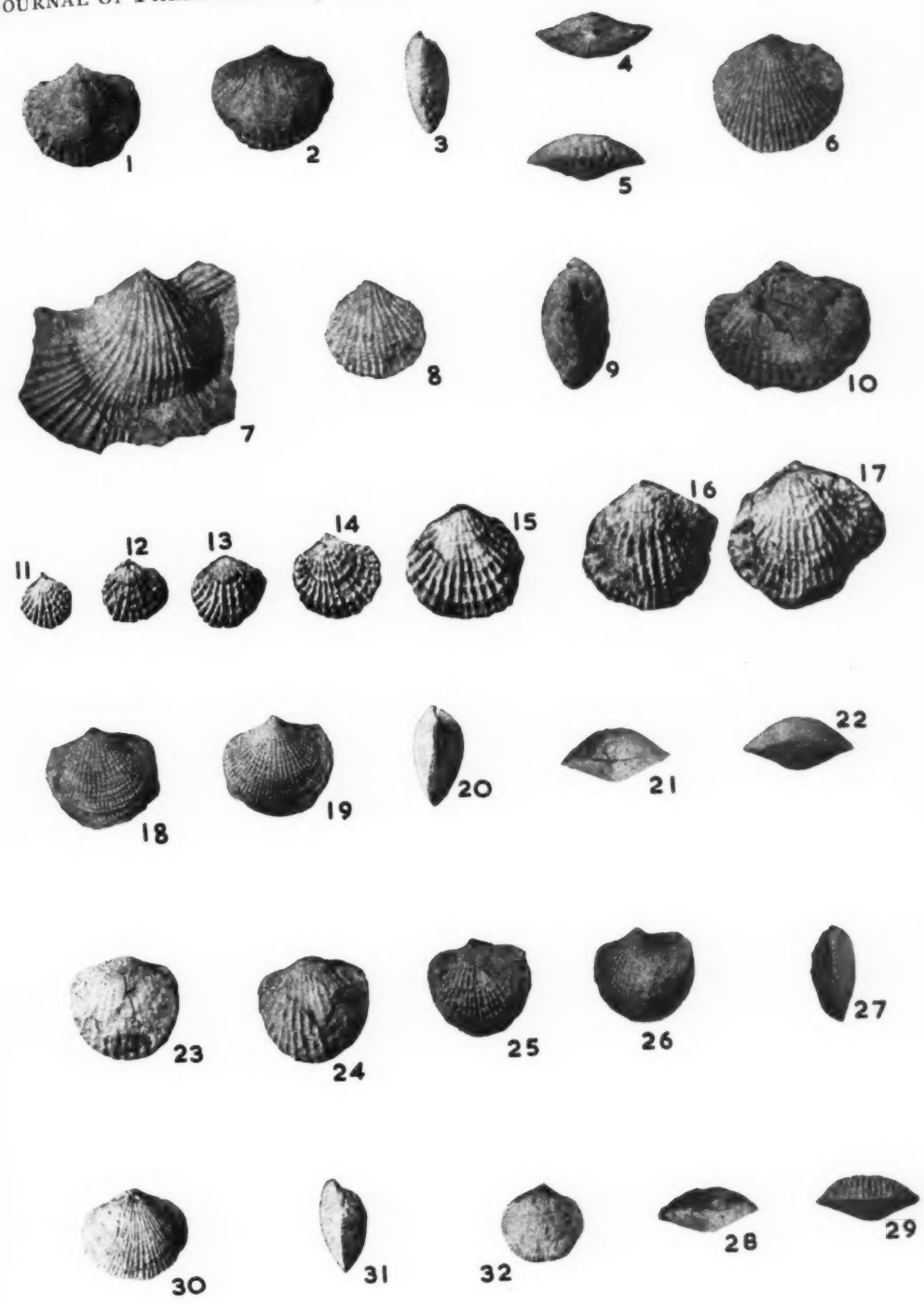
EXPLANATION OF PLATE 102

FIGS. *1–17*—*Atrypa aspera prideri* Coleman n. subsp. *1–5*, ventral, dorsal, lateral, posterior and anterior views of syntype 26126l, U.W.A., from east side of north entrance to Minyu Gap, Rough Range area, Kimberley Division, West Australia. *Atrypa* limestone. *6*, dorsal aspect of syntype 26261a from just south of Long's Well, same general locality. *7*, specimen showing marginal flange, exact locality unknown, same general locality. *8*, ventral aspect of young specimen, more elongate than mature forms, from near Long's Well, same general locality. *9–10*, lateral and dorsal views of syntype 26261c, from just south of Long's Well, same general locality. *11–17*, growth series of specimens from locality 20, Williambury Station, upper part of the Minilya River, near the eastern edge of the North-West Basin, West Australia. (p. 684)

18–29—*Atrypa parva* Coleman n. sp. *18–22*, dorsal, ventral, lateral, posterior, and anterior views of syntype 26294a, from low hill of yellow limestone on front of main limestone cliff, 1½ miles south-west of Long's Well, Rough Range area, Kimberley Division, West Australia. *Atrypa* limestone. *23–24*, ventral and dorsal views of specimen showing extreme coarseness in costation. *25–27*, ventral, dorsal, lateral, posterior, and anterior views of syntype 26294d, same locality, showing costae of intermediate coarseness. (p. 685)

30–32—*Atrypa* n. sp. *30–31*, dorsal and lateral views of specimen 26123c, from west side of north entrance to Minyu Gap. *Atrypa* limestone. *32*, dorsal view of smaller specimen, same locality. (p. 687)



Coleman, Australian *Atrypa*

standard. These and other difficulties make any positive statement as to relationships between species of other areas and the local ones, rather presumptuous and probably incorrect.

It can be seen from the systematic descriptions that the number of instances where foreign species show affinities with one or the other local species does not show any increase for those areas nearer the local area. So that in a general way it can be stated that a thorough study of the literature indicates that the West Australian *Atrypa* species have as strong affinities with the European forms as with the intermediate areas of Asia. In this *Atrypa* agrees with the associated fauna, as consideration of the Devonian faunas of Western Australia suggests general European relationships and derivation (Teichert, 1943).

ACKNOWLEDGMENTS

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PALEONTOLOGICAL NOTES

A NEW EDRIOASTEROID FROM THE MIDDLE ORDOVICIAN OF NEW YORK

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INTRODUCTION

While engaged in field work for a faunal study of the Amsterdam limestone in the Mohawk Valley of New York State, the writer found a single rather well preserved specimen of an edrioasteroid adhering to the surface of a bryozoan. The fossil was found along an undulating bedding plane 4 feet above the top of the Amsterdam limestone. These beds are interpreted by Kay (1937, p. 260) as Hull (Middle Ordovician) in age and he designates the strata in question as the Larrabee limestone member of the Hull formation of the Trenton group. The specimen was collected in an abandoned quarry ¼ mile east of Manny Corners, a small hamlet 2 miles northeast of Amsterdam, N.Y. An extended search for further material proved futile, therefore the succeeding description is based on but one specimen.

Edrioasteroids have never received much intensive investigation largely because of their rarity. They are known to have a stratigraphic range from the Middle Cambrian to the Mississippian with their apex of development, both as to diversity and abundance, during the Ordovician period. Much speculation has arisen over their position in the system of nomenclature and it is regretted that nothing new concerning this can be offered here.

The outstanding student of the Edrioasteroidea, R.S. Bassler, (1935, p. 1; 1936, p. 1) to whom we are indebted for the classification of this group, has observed that the direction and extent of curvature of the ambulacra (rays or food grooves) as well as the plate structure of the rays, interradii, and oral area remain constant for a genus and thus afford good generic characters whereas the amount of imbrication of the interambulacral plates and even the number of arms may vary in the same species. With this information in mind, it was found that the specimen in question does not agree with those previously described in the literature. As all of the known species of Edrioasteroidea are given in Bassler's papers 1935, 1936, careful examination of these and the succeeding literature discloses that the specimen represents a new genus.

SYSTEMATIC DESCRIPTION

Class EDRIOASTEROIDEA Billings 1854–58
Family HEMICYSTITIDAE Bassler 1936
Genus BASSLERIDISCUS Fisher, n. gen.
BASSLERIDISCUS MOHAWKENSIS
Fisher, n. sp.

This genus is named in honor of Dr. R. S. Bassler, Curator of Invertebrate Paleontology, U.S. National Museum, ardent student of the Edrioasteroidea. It is he who has contributed more to their clarification and understanding than any other person. The species is so named because of its geographical occurrence.

The sole specimen exhibits the following characteristics: Theca is a slightly dorsally crushed disco-globular sac having a diameter averaging 15 mm. Ambulacra are strongly curved and extend completely around to the aboral side having a length of from 12–16 mm. and a width of from 1.5 mm. at the extremity to 2.5 mm. at the junction with the oral area. Conforming to the acceptable nomenclature of the ambulacra (rays) beginning with the arm to the left of the anal opening, (1) left posterior, (2) left, (3) anterior (opposite anal area), (4) right, (5) right posterior, rays 1–4 exhibit sinistral curvature while the fifth, the right posterior, curves dextrally. The sharply elevated ambulacral covering plates are elongated and pentagonal in outline, existing in two rows alternating and interlocking along a median line. In this respect it resembles *Carneyella* Foerste but the arms are much longer and more strongly curved than in that genus. The oral area consists of three plates, the

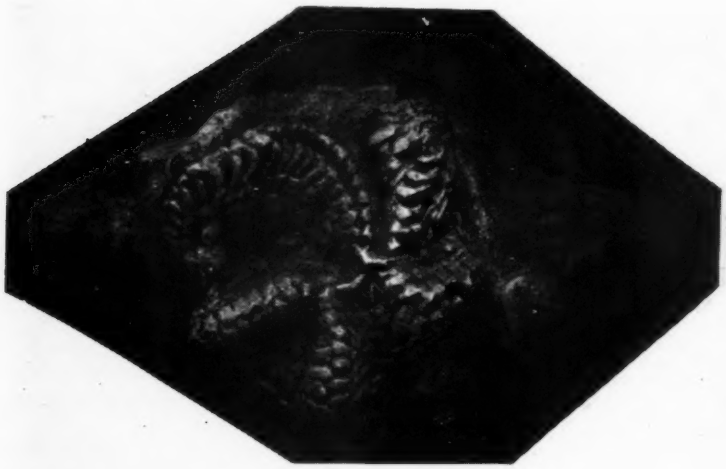

FIG. 1

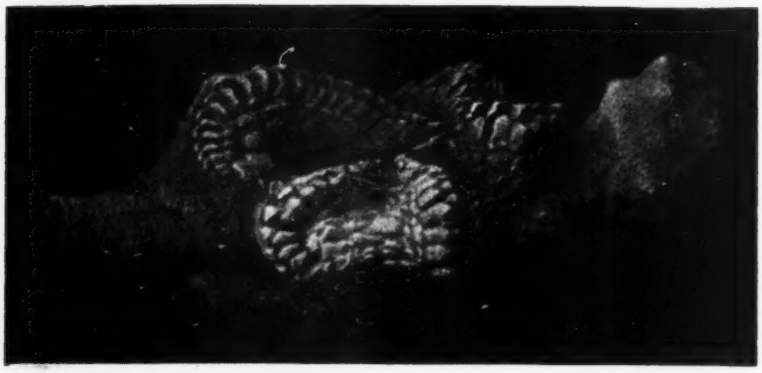

FIG. 2

FIGS. *1, 2*—Oral and oblique lateral views of *Bassleridiscus mohawkensis* Fisher, n. gen., n. sp., ×3. Note particularly the large plates in the oral area and the sharply elevated ambulacral plates.

plate between arms 1 and 5 being the largest, the smaller two equidimensional and occurring between arms 2 and 3 and 3 and 4, respectively. Unfortunately the anal area is indistinct but it does appear as a slightly elevated pyramid. The interambulacral plates are slightly imbricating and polygonal to circular in outline ranging from 0.25 mm. to 1 mm. in diameter. At the periphery the plates are more strongly imbricating but this may be due to the slight dorsal compression of the specimen. *Bassleridiscus* superficially resembles *Edrioaster* Billings but in the latter the ambulacral plates are depressed rather then elevated, and two rows of flooring plates are present. The new genus differs from *Isorophus* Foerste, a more abundant Trenton edrioasteroid, in that the latter possesses numerous small plates in the oral area and frequently an extra row of inter-

mediate covering plates on the ambulacrum itself (Bassler, 1936, p. 16). Furthermore, the rays of *Bassleridiscus* are longer and more strongly curved and these features, together with the pronounced elevation of the ambulacral plates, seem characteristic for the proposed genus.

Genotype and only known species to date: *Bassleridiscus mohawkensis* from the basal Hull of the Mohawk Valley (Larrabee limestone) ¼ mile east of Manny Corners, a small hamlet 2 miles northeast of Amsterdam, N.Y. Specimen No. DE-1 in the writer's collection (see figs. 1, 2).

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PALEONTOLOGIC TECHNIQUES

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Work with small Ordovician trilobites preserved as siliceous replacements in limestone which are freed from the matrix by etching with hydrochloric acid has led to the development of several techniques which might prove of value to other paleontologists. These include: 1) Use of a simple 3-axis stage to orient specimens for examination under the microscope or for photographing. 2) Use of aluminum-foil tweezers for handling delicate microscopic and semi-microscopic fossils. 3) Use of an acid cleaning solution to remove coherent organic and other insoluble material from delicate silicified fossils. The first two techniques should be useful for micropaleontologists in general; the third should find application in cleaning siliceous fossils from certain types of impure limestone. The three techniques will be described briefly.

A SIMPLE 3-AXIS STAGE FOR SPECIMEN ORIENTATION

The trilobites which have been the object of the writer's attention present a number of problems to the paleontologist with regard to methods of handling, study and photographing. The specimens are microscopic and semi-microscopic in size. They consist of the silicified, dissociated pieces of the trilobite exoskeleton. They are uncrushed and, generally, quite convex. Many of the specimens are either asymmetrical to begin with or have been broken. Thus, they are of varied and irregular shapes. This makes it difficult to lay them on slides or to prop them against other objects in particular orientations for examination or photographing. It has been found that the most satisfactory way of handling these objects is to cement them to the heads of insect pins. The pins, stuck in a cork or ball of Plasticine, can then be handled safely. Nevertheless, it remains cumbersome to orient the specimens in specific positions to be studied, sketched or photographed.

Entomologists have been confronted with somewhat the same problems in the manipulation of insects under the microscope and have used a simple mechanical device which permits one to orient an insect in any desired position and to hold it thus as long as necessary. With the principle of this device as a guiding idea, the apparatus described below and illustrated in figure *1* was constructed from odds and ends of materials on hand in a home shop with a moderately well stocked "some-day-it-may-come-in-handy" drawer.

To the end of the shaft of a radio knob (A) was brazed the lead-holding tip of an old pencil drawing compass (B), equipped

with a set screw (C). The hole to receive the lead was filled in with solder and a new hole (of diameter designed for an insect pin) was drilled, care being taken that it was accurately centered to line up with the axis of rotation of the knob. The knob was then attached to one end of a bent piece of light copper rod (E) which, in turn, was connected at the other end to a vertical support (F) by means of a horizontal bolt with a small butterfly nut (G). The length and arcuation of the rod were designed so that the head of an insect pin (D), set in its holder, would lie on the axis of rotation of the horizontal bolt. The vertical support was attached to a thin metal plate to act as a base plate (H).

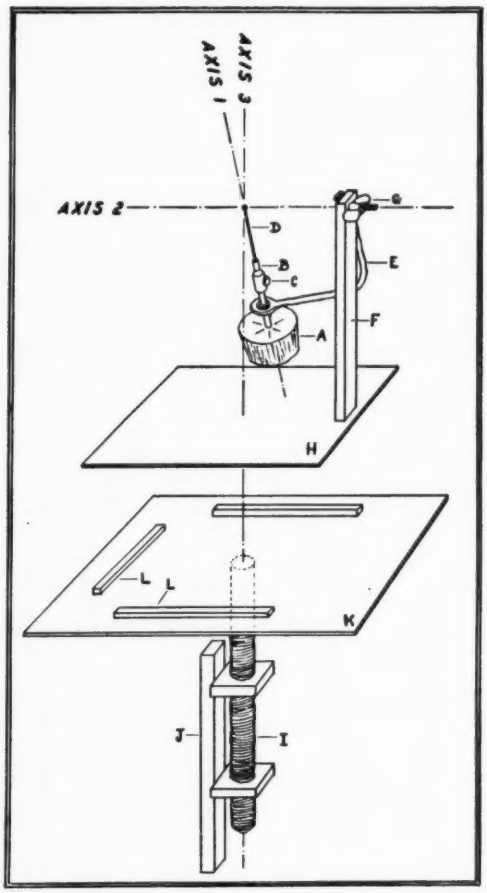

FIG. 1—A simple 3-axis stage to orient semimicroscopic specimens for examination under the microscope and for photographing.

As so far described the essentials of the apparatus are complete. The freely movable metal base plate which can be set on the microscope (or camera) stage provides one axis of rotation, the horizontal bolt a second, and the radio knob a third. For examination, it is possible to set and hold a specimen which has been mounted on an insect pin in any position or to rotate it slowly and evenly about any axis without having to handle the specimen itself. For photographing, a specimen can be coated with a whitening medium (ammonium chloride or magnesium oxide), oriented in the apparatus beneath the microscope, then placed before the camera and photographed.

It has been found that a further refinement is of assistance, particularly in the photographing of specimens requiring moderately high magnification. In such cases a small lateral movement of the specimen before the camera moves its image a large distance on the focusing glass of the camera. To make possible a smooth rotation about a vertical axis (represented above by the freely movable base plate) and to eliminate this objectionable lateral movement, a vertical bolt (I), supported by two nuts fastened to an upright (J), was positioned so that its axis of rotation aligned with the axis of the camera. To the top of this bolt was attached a second metal plate (K) with guides (L) to receive the base plate of the apparatus and to hold the latter with the pin head in line with the axis of rotation of the bolt below. Thus, a truly 3-axis universal motion is possible and the specimen can be precisely rotated for a view from any direction without a lateral change in its position.

ALUMINUM-FOIL TWEEZERS

The silicified specimens dealt with by the writer are small, thin and fragile, many with long and delicate spines. After washing, the insoluble residue from a limestone block must be spread out and carefully examined under a microscope and the trilobite fragments picked out. With sturdier specimens than these this can be accomplished with a needle point touched to beeswax and then pressed against a specimen. However, the slight pressure necessary to make the bees-

wax adhere to a delicate specimen may be sufficient to crush it or at least to break off the longer projections. A moistened camel's hair brush can be used with greater success, but here arises the difficulty of detaching the specimen from the brush. This involves wiping or jarring the specimen off and, again, risk of breakage is high.

It was called to the writer's attention by Dr. Thomas W. Amsden of The Johns Hopkins University that a technique had been in use at Yale University for the handling of delicate micro-specimens. This consisted of extending the points of a small pair of tweezers with short sections of a watch hair-spring cemented to their tips. The writer has used such a pair of tweezers with much more success than a waxed needle or a camel's hair brush and has found that specimens may be handled with a very positive grasp, practically without risk to even the finest and most delicate structures.

However, a watch hair-spring is fragile. It cannot be kinked more than a couple of times in one place without breaking, and occasional kinking is inevitable. It cannot under any circumstances be touched to the skin or it immediately begins to rust and, even with the most careful treatment, rust very soon comes. One hot summer day, while idly fingering a colored cellophane straw, such as can be obtained in almost any grocery store, the writer was struck with the notion that the thin thread of aluminum foil used to decorate and give strength to the straw might serve all of the purposes of a watch hair-spring in this connection without its shortcomings. Experimentation verified this opinion. In the short lengths which are required (0.5 to 0.75 cm.) the aluminum foil possesses quite sufficient elasticity. Sharp flexures where the aluminum tips join the tweezer points proper can be straightened repeatedly with another pair of tweezers without breaking and there is, of course, no deterioration due to oxidation.

The speed and firmness with which small objects—be they trilobite fragments, ostracodes, or Foraminifera—may be grasped, and the ease with which they may be set down in the desired spot should commend the use of such modified tweezers to all micropaleontologists. Whereas hair-spring points, with care, may last a week, the aluminum points will last for months of hard use.

AN ACID CLEANING SOLUTION

A cleaning fluid consisting of a solution of potassium dichromate, concentrated nitric and sulphuric acids is used in every organic chemistry laboratory to remove stubborn films of organic compounds from the insides of glass containers and tubing. The limestones from which the writer has recovered silicified fossils contain moderate to large amounts of extremely fine-grained inorganic material which is held together in stringy masses by organic material when the limestone is etched with acid. These masses are not coherent enough to pick out manually and many are attached to or caught in parts of the fossil remains. It is a laborious and time consuming task to pull the material from the fossils with forceps under water and, once dry, the debris sticks fast to the rough fossil surfaces and cannot be removed.

It has been found expedient to wash the insoluble residue after etching, decanting off as many fine insoluble impurities as possible after agitation with a current of water, then to dry the remainder (to prevent dilution of the cleaning fluid), cover with cleaning solution and let stand for a few minutes or a few hours, depending upon the amount and tenacity of the foreign particles. After this, washing in clear water leaves the fossils clean and completely free of objectionable debris. Care must, of course, be exercised in handling this extremely corrosive solution.

THE PELECYPOD GENUS *VLASTA* IN THE ORDOVICIAN OF NORTH AMERICA

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INTRODUCTION

Numerous examples of a large pelecypod of striking appearance were brought to me recently for identification by Mrs. Helen Bush, a member of the teaching staff of the Division of Education in the Royal Ontario Museum. The material was collected by Mrs. Bruce Metcalfe from Upper Ordovician strata of the Humber member of the Dundas formation, exposed along the banks of the Humber river, on the Metcalfe property at Thistletown, Ontario, Canada.

My first impression, upon seeing the collection which consists of over twenty specimens, was that it was foreign to the district, the pelecypod in question having somewhat the appearance of a moderate sized Cretaceous *Inoceramus*. This idea was quickly dispelled, however, when the associated fauna was noted, the following well known local species being recognized:

Byssonychia praecursa Ulrich
Cymatonota cf. *parallela* (Hall)
Modiolopsis cf. *ovata* (Conrad)
Psiloconcha inornata Ulrich
Whiteavesia pholadiformis (Hall)
Whitella hindi (Billings)

In an effort to identify this unique pelecypod every North American reference pertaining to Ordovician *Pelecypoda*, known to me, was consulted without avail. Several specimens were submitted to Dr. Alice E. Wilson, Geological Survey of Canada, whose research in the Ordovician is well known. To Miss Wilson I am indebted for suggesting a possible relationship with *Vlasta bohemica* Barrande, from the Silurian, Étage E, bande e_2, Dworetz, Bohemia. After duly considering the suggestion, I am in agreement with this opinion.

Dr. Aurèle LaRocque, Ohio State University, also kindly commented on a few of the best specimens. He states in a recent letter "after examining the specimens in detail, I agree with you that they are remarkably close to *Vlasta* Barrande."

In view of the foregoing it is my intention to describe the species as *? Vlasta americana* n. sp. Since the genus *Vlasta* may not be well known to paleontologists on this continent, the main characteristics, as set forth by Barrande, are given in the following translation:

Genus VLASTA Barrande

Système Silurian de la Bohême, vol. 6, Texte 1, p. 167, 1881.

From external features the genera *Vlasta* Barrande and *Pholadomya* Sowerby show close affinities. The characteristics of the latter genus, as given by M. Chenu, are as follows:

Shell thin (transparent) generally transverse or triangular, tumid, equivalved, inequilateral, gaping at the extremities, but especially at the posterior. Anterior end short, rounded or truncated; posterior end more or less dilated.

Hinge simple, (without teeth, having upon each valve a marginal nymph, giving insertion to a short, external ligament).

Beaks prominent, very closely approximated. (Muscle impressions rarely well marked. Pallial impression with a very deep, anal sinus.)

Barrande goes on to state that for the most part these characteristics apply exactly to species of the genus *Vlasta* but some of them cannot be recognized in the various species; for instance, those which appear in parentheses in the above formal description and which apply mainly to the internal surface of the shells. Furthermore, the relationship between the anterior end and the direction of the beak is left in doubt; this feature was not defined by M. Chenu for *Pholadomya*. Among the 28 species of *Vlasta*, there are six species in which the beak is turned towards the smaller end, while it is inflected towards the larger end in 17 species. The direction is doubtful in five species. It should be noted, however, that typical species show the beak pointing towards the larger end, notably, *V. bohemica*, *V. pulchra* and *V. tumescens*.

No specific observation can be made upon the hinge of the various species; it is noted

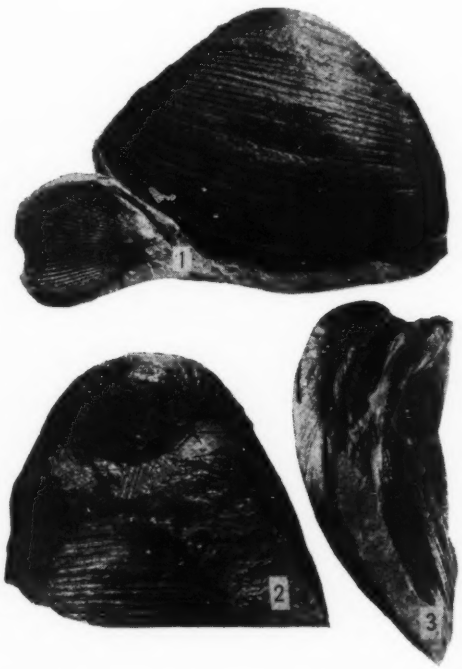
merely that, as a whole, it forms a nearly straight line composed externally of two feebly convex arcs which come together under the beak, in a very obtuse reëntrant angle.

The close fusion of the shell with the rock does not permit a differentiation of teeth on the hinge. But, as an exception, some specimens of *Vlasta pulchra* show, below the beak possible teeth, the number of which varies from three to four.

Several species show longitudinal ornamentation, interspersed among the concentric zones.

The largest species *V. superba* measures 90 mm. in height and 130 mm. in length.

All 28 species occur in the upper part of "bande e_2."



FIGS. *1–3*—?*Vlasta americana* Fritz, n. sp., ×½. *1*, a folded left valve with *Byssonychia praecursa* Ulrich in association; cotype 26647, Royal Ontario Museum of Palaeontology. *2*, inside of a right valve showing arcuate hinge; cotype 26648. *3*, A much crumpled left valve showing an elongate area (?escutcheon) behind beak with thickening along its lower margin; cotype 26649.

FIG. *4*—?*Vlasta americana* Fritz, n. sp., ×½. Two closely appressed specimens, the uppermost, a right valve, is the least distorted in the collection; cotype 26646, Royal Ontario Museum of Palaeontology.

DESCRIPTION OF NEW SPECIES
?VLASTA AMERICANA Fritz, n. sp.
Text-figures 1–4

General Remarks.—The material upon which the following description is based, while spectacular in appearance, is not well preserved. In the first place the fossils represent, for the most part, external casts. No internal casts or moulds are present. Furthermore, the most extreme distortion is exhibited, many of the specimens being folded, bent, crumpled, or dinted in a most extraordinary manner. The shells must have been very thin, yet sufficiently plastic to permit extreme deformation by pressure without yielding to actual fracture.

In view of the above the following specific characters are recorded with considerable reservation.

Specific description.—Shell large, equivalved, inequilateral. Owing to distortion exact measurements cannot be procured but length appears to vary from 100 mm. to 120 mm., height from 90 mm. to 105 mm. Surface marked by coarse, regular,

concentric growth lines. Most of the specimens show indications of radial ornamentation but it is believed that these markings represent puckers or cracks due to pressure.

Umbonal region broad and tumid; beaks prominent, apparently rostrate, anterior in position, curving backwards towards posterior region. Anterior short, posterior extended, each extremity truncated. From these truncations margin of shell becomes distinctly arcuate ventrally.

Margin of hinge arched both anteriorly and posteriorly but nature of hinge beneath the beaks not revealed. Three specimens show an elongated area behind the beak and on one specimen there is the suggestion of a shorter area in front of the beak, thus implying an escutcheon and lunule. Along lower margin of one of the so-called escutcheons there is a distinct thickening. Teeth not observed.

Relationships.—The closest affinities of the present species are with *V. bohemica*, the most typical species found in the Bohemian basin. *?V. americana*, however, appears to be more trigonal in shape, is larger on the whole, lacks true radial ornamentation, and possesses a possible lunule and escutcheon.

Occurrence.—Humber member, Dundas formation, Thistletown, near Toronto, Ontario.

Cotypes.—Nos. 26646, 26647, 26648, 26649, Royal Ontario Museum of Palaeontology, Toronto, Ontario.

SHIDELERITES, A NEW SILURIAN OSTRACODE GENUS

R. W. MORRIS AND B. L. HILL
Washington University, St. Louis, Missouri

The new ostracode genus *Shidelerites* was discovered by the senior author while studying the microfauna of the Middle Silurian Waldron shale of Indiana. Several new species were found but, because of unavoidable delay in preparation of a faunal paper, it was thought best to bring this peculiar form immediately to the attention of interested workers.

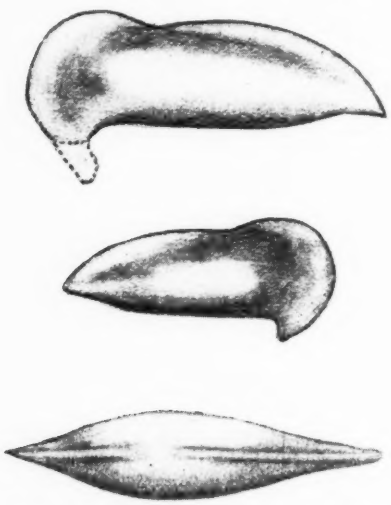


FIG. 1—*Shidelerites typus*, Morris & Hill, n. sp. Top, left valve of adult holotype with ventral beak restored from a paratype. Middle, right valve of a young paratype. Bottom, dorsal view of holotype. All about × 28.

The authors wish to thank Mrs. Betty Kellett Nadeau for her helpful suggestions and constructive criticism of the manuscript.

The illustrations are camera lucida drawings by the junior author.

Genus SHIDELERITES Morris & Hill, new genus

Type species.—*Shidelerites typus* Morris and Hill, new species.

Elongate, posteriorly acuminate Ostracoda with anteroventral "beak" and sinuate dorsal margin which is keel-like along the postdorsal portion.

The anterior beak of *Shidelerites* is suggestive of the Cypridinidae, but it lacks the opening for protrusion of the anterior appendages characteristic of that family. It may eventually prove necessary to erect a new family for the reception of this genus, but such a step seems premature at the present time. In view of the fact that

Shidelerites is not close to any known genus, comparison would be superfluous.

Shidelerites is named in honor of Dr. W. H. Shideler of Miami University, Oxford, Ohio, who first discovered the fossiliferous lens that yielded the type specimens.

SHIDELERITES TYPUS Morris & Hill, n. sp.
Figure 1

Carapace elongate, posteriorly acuminate; valves equal; anterior margin evenly rounded, produced ventrally into a thin, delicate, beak-like process; dorsal margin convex at either end, concave just in front of midlength; posterior convexity is due to presence of elevated keel-like structure along postdorsal margin; ventral margin straight or slightly convex for most of its length, concave near acuminate posterior and just behind anterior beak; greatest length well below midheight, near ventral margin. Spindle-shaped in dorsal view, tapering gently to sharply pointed ends; greatest thickness anterior of midlength. Surface smooth. Hingement unknown.

Young individuals are shorter and narrower posteriorly than adults and have a straighter ventral margin.

Measurements.—Holotype: length 1.81 mm., height at midlength 0.51 mm.; small paratype: length 1.35 mm., height at midlength 0.40 mm.

Occurrence.—Waldron shale, Middle Silurian. Fairly common in small abandoned quarry on the north side of Route 46, 0.7 mile west of Hartsville, Indiana; also rarely found on Deer Creek, just above its junction with Conns Creek, about 2 miles south of Waldron, Indiana. Extensive search in the equivalent Newsom shale of Tennessee and Massie shale of Ohio has not yielded specimens of *Shidelerites*.

Repository.—Holotype and figured paratypes; United States National Museum. Unfigured paratypes: American Museum of Natural History; University of Cincinnati; Paleontologisk Museum, Oslo, Norway; Senckenberg Institute, Frankfort-am-Main, Germany.

Note: The anteroventral projection of *Shidelerites* and its acuminate posterior suggest that it may belong to the family Bairdiidae. Certain Devonian *Bairdites* seem to show a slight anterior protuberance and *Bairdianella*, like *Shidelerites*, has no dorsal overlap. A similar anteroventral projection is found on *Cypridea* but *Shidelerites* otherwise little resembles that genus. For the present I would refer *Shidelerites* to the Bairdiidae —BETTY KELLETT NADEAU.

JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 5, P. 700, SEPTEMBER 1951

NOMENCLATURAL NOTES

TRYONELLA, A NEW GENERIC NAME FOR *TRYONIA* STEPHENSON, PREOCCUPIED

L. W. STEPHENSON
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In my paper "The larger invertebrate fossils of the Navarro group of Texas" published in 1941 as University of Texas Publication no. 4101, I described on pages 331, 332, pl. 62, figs. 8, 9, the new genus and species *Tryonia valida* Stephenson, from the Nacatoch sand (Maestrichtian) near Corsicana, Texas. Dr. Harold E. Vokes has kindly informed me that the name *Tryonia* Stimpson was proposed for a gastropod species in 1885, in American Journal of Science, vol. 1, page 54. I therefore propose the generic name *Tryonella* to replace the preoccupied name, with *Tryonia valida* Stephenson as the genotype.

A NEW NAME FOR *UNIO REESIDEI* YEN

TENG-CHIEN YEN

Since the publication of "Some Lower Cretaceous pelecypods from Pryor, Montana," Miss B. N. Nicolson, a cataloguer of the U. S. Geological Survey called attention to the fact that the name *Unio reesidei* Yen (Amer. Mus. Novitates, no. 1481, p. 3, fig. 3, 1951) is preoccupied by that of an Upper Cretaceous species which Dr. T. W. Stanton (U. S. Geol. Survey Prof. Paper 98-R, p. 314, pl. 81, fig. 1, 1916) described from the Fruitland formation. I propose hereby that the name of the Lower Cretaceous species be changed to *Unio reesideanus* Yen.

JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 5, PP. 701–702, SEPTEMBER 1951

SOCIETY RECORDS AND ACTIVITIES

NOMINATIONS FOR MEMBERSHIP

In accordance with Article 3, Chapter 1, of the By-Laws of the Paleontological Society, the Secretary submits the following nominations for membership in the Society. They have been approved by the Council.

RICHARD DOLPHIN ALEXANDER, Box 979 WC, Norman, Okla. G. B. Huffman, J. W. Stovall.

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CIFELLI, RICHARD, Dept. of Paleontology, University of California, Berkeley, Cal. J. W. Durham, R. M. Kleinpell.

FREZON, SHERWOOD EARL, R.F.D. 4, Albion, Mich. E. C. Stumm, G. M. Ehlers, L. B. Kellum.

HUTCHINSON, ROBERT D., Geological Survey of Canada, Ottawa, Canada. L. M. Cline, L. R. Laudon.

JOHNSEN, JOHN HERBERT, Geology Dept. Vassar College, Poughkeepsie, N. Y. A. S. Warthin, K. E. Caster.

PECK, JOSEPH HOWARD, JR., Museum of Paleontology, University of California, Berkeley 4, Cal. J. W. Durham, R. A. Stirton.

POPE, JOHN KEYLER, Galbraith Rd., Box 369, RR. 10, Cincinnati 27, Ohio. K. E. Caster, W. B. Macke.

RISLEY, GEORGE A., California Research Corp., La Habra, Cal. L. M. Cline, L. R. Laudon.

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JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 5, PP. 703–705, SEPTEMBER 1951

REVIEWS

THE MORPHOLOGY OF OSTRACOD MOLT STAGES, by R. V. Kesling. Biological Monograph, vol. 21, nos. 1–3, University of Illinois Press, 1951.

This valuable book consists of 324 pages, 116 of which are text that include 36 figures and 8 tables. It discusses in detail the anatomy and biology of the fresh-water living ostracode *Cypridopsis vidua* (O. F. Müller). This species is adapted to a variety of environments, is parthenogenetic, cosmopolitan in distribution, and can be raised in an aquarium. It is a sad commentary on the neontologists that this much needed work should be done by a paleontologist, and it is to Dr. Kesling's credit to have undertaken it. Because of his paleontological background, he paid special attention to the relationship of the body of the animal to the shell structure, and the changes in shape of the shell from molt to molt.

The excellent drawings of different views of the animal (figs. 1–7) vividly portray its anatomy and shell structure. Each drawing is accompanied by a smaller schematic drawing on which the significant features are named. This added feature makes the figures more comprehensible without cluttering up the drawing with arrows and names. Figures 8 through 31 are drawings of the individual appendages and organs, including the muscular elements. Figure 32 is an original large scale diagrammatic section through the anterior ventral part of the right valve as seen from the front, and shows the shell wall, marginal structure of the valve, as well as the various cell components. Unfortunately, the "line of concrescence" is not indicated. This figure, however, may prove useful in interpreting fossil forms.

Pages 1 through 3 deal with the taxonomy of the species. It is indeed unfortunate that the author did not check the originals of several important publications which he lists in his synonymy and discusses under the genus, because both Brady (1867, p. 117) and Brady and Norman (1896, p. 745) do not contain the facts attributed to them. A genotype should have been designated.

Pages 4 to 78 contain a detailed description of the *Cypridopsis vidua*. We like the general outline of the parts of the body which, however, is not keyed in with the excellent drawings previously mentioned. The author then discusses each appendage, the endoskeleton, the digestive, nervous, and reproductive systems, the various glands, and the attachment and arrangement of the muscles. Of particular interest to paleontologists is the description of the epidermis, points of attachment of the muscles to the shell, and the secretion of the shell. He describes two experiments (pp. 72–73). Fassbinder (1912, p. 563) fed a culture of a normally smooth-shelled form (*Cypris pubera* O. F. Müller) on a diet of crushed snails, rich in calcium, which caused the animals to develop a secondary thickening of the shells, marked by conspicuous anterior and posterior protuberances. Wohlgemuth (1914, p. 21) conducted a converse experiment with *Cyprinotus incongruens* Ramohr. Animals were fed on a near-starvation diet, and developed saddle-shaped indentations in the posterior dorsal border.

Pages 79 to 93 contain descriptions, in part based on original observations, on egg-laying, the process of molting, temperature tolerance, rate of reproduction, and other biologic functions. This section is valuable to the paleontologist because it gives him the necessary background to help interpret fossil forms.

Pages 94 to 100 describe the growth stages of the species based on the addition and development of the appendages as the animal grows to maturity, and pp. 110 to 114 discuss the relation of appendages and internal organs in instars to the shape of the valves. This excellent section would have been enhanced, in our opinion, had Dr. Kesling included more details on the development of marginal shell structure and of the muscle scar pattern as the animal grows. Le Roy (1945, figs. 1, 2) shows a progressive development of the "muscle node" in growth stages of species of *Cythereis*. We infer that this section as well as the section on statistics that follows, are based on the assumption that there are no molt stages between growth stages, and that there is no post-maturity molting.

Pages 101 to 109, and pp. 115, 116 consist of a statistical discussion that includes five charts based on 500 specimens selected at random from the residue in the bottom of the aquarium. The charts showing size variation and development of growth stages are inadequately labeled, and the statistical methods are not described in the text. The discussion of the formulae for calculating growth rates and the relation of development of appendages and organs to growth of the carapace impresses us as being more of theoretical than of practical value. The conclusions seem to be valid, but appear to be based more on observation than on these statistics. Dr. Kesling's conclusion that the length-height ratio is not a safe criterion for conspecific determination is a significant contribution.

The bibliography (pp. 117–126) contains 164 references. Some of the dates are erroneous: for instance, Claus, 1868, should read "1872." Other discrepancies were noted in comparing with the bibliography given by Hoff (1942, pp. 169–174).

The 96 plates containing 419 photographs of serial histologic sections could, in our opinion, have been considerably reduced in number without affecting the value of the publication. The text refers to photographs on which the features discussed are not named. Because of the difficulty in making microtome sections of ostracodes, a description of the technique used would have helped subsequent workers.

In conclusion we can state that Dr. Kesling has made a valuable and important contribution to the study of ostracodes. The inestimable value of this book is proven by the fact that Scott (1951, p. 323) was able with the aid of figs. 5 and 5a (p. 10) to interpret the accessory muscles of *Eoleperditia fabulites* (Conrad).

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I. G. SOHN AND JEAN M. BERDAN
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PRACTICAL INVERTEBRATE ANATOMY, by W. S. Bullough. 462 pp., 168 figs. London: Macmillan. 1950. $4.50.

This excellent book is hard to pigeonhole. It is essentially a laboratory manual, but if it is so called, then it must be added that it is a manual plus. Dr. Bullough discusses 122 genera, from the Protozoa to *Amphioxus*. For each he describes methods of culturing or otherwise keeping the animal for study as a living organism, and methods of preparation for detailed study (staining techniques, etc.). Notes are added on the living habits of each animal, its habitat, its food. The diagnostic characters are succinctly given for each phylum, and for each of the subdivisions mentioned.

Then follow detailed directions for dissection and study. Those this reviewer went over in detail are very complete and admirably lucid. The illustrations, all original, are semidiagrammatic but very true to nature, and the student will find no trouble in correlating them with his specimens. Artistically they combine a uniformly pleasing aspect with a fine clarity of draughtsmanship. The labelling is very full, and the names are incorporated in the figures directly. Usually this is advantageous, but in a few cases it results in an unpleasing crowding.

This book is brought to the attention of paleontologists as one answer to the problem of the student who comes to courses in our field with inadequate preparation in zoology. Bullough's book is so clear that such a student can easily work through it, or through

the parts he wants, with a minimum of assistance. Here are detailed studies of *Lingula* and *Terebratella;* of a crinoid, a starfish, a brittle-star, three echinoids and a holothurian; and so on through the phyla. The only omission I notice is that of the ostracodes.

All in all, a fine book, and, as book prices go today, a rare bargain.

G. WINSTON SINCLAIR

HANDBOOK OF PALEONTOLOGY FOR BEGINNERS AND AMATEURS: PART 1, THE FOSSILS, by Winifred Goldring. New York State Museum Handbook 9 (2nd edition, revised) (1950). Albany, N. Y., May 17, 1951, $1.00.

In 1929 the first edition of this handbook was issued in a printing of 2,000 copies. That it had value and appeal for amateurs, students and professionals in paleontology was demonstrated by the sale of the whole edition within a few years. Since the printer's symbol on the flyleaf indicates that only 3,000 copies of the new edition were printed (despite the fact that the number of people interested in paleontology has doubled since 1929) it seems likely that this too will rapidly go out of print.

Written primarily for the people of New York State, the treatment of the various groups of fossils is weighted toward Paleozoic marine life. The plants receive 57 pages of description, while invertebrates are accorded 163 pages and vertebrates 77 pages. Material on the nature, significance and collection of fossils requires 47 pages.

The 97 figures contain up to a dozen illustrations each, principally in the form of line cuts. These are essentially unchanged from the earlier edition. Text material has been expanded, and the new handbook is 394 pages in length, 38 pages more than its predecessor. Changes in scientific names since 1929 have been incorporated, although an effort has been made to connect old and new names by citing both.

Dr. Goldring is to be congratulated for preparing this revised edition, and the State of New York (albeit 15 years belatedly) is to be commended for making it available to the public at a price within the reach of all. Those ordering it should send the price ($1.00) to the New York State Museum, Albany 1, New York, but should make the remittance payable to the New York State Education Department.

A. S. WARTHIN, JR.

JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 5, PP. 706–708, SEPTEMBER 1951

NOTICES

EXCHANGES, FINANCIAL AND GEOLOGICAL

Due to the world situation it is ever more difficult for many of the foreign members of the Paleontological Society to remit their annual dues. Some colleagues have consequently fallen several years in arrears. The suggestion has come from several of these colleagues that some of the dollar-possessing members may be willing to help them out of this difficult situation by paying their annual dues to the Society in exchange for publications and/or specimens. This arrangement has operated for several years by personal contact between members. At this time two foreign members, one in Palestine and one in Japan, solicit such an exchange. Please write to the Treasurer or the Secretary for particulars.

COMMITTEE ON AMATEUR PALEONTOLOGY

The Council of the Paleontological Society took formal action at the 1949 meeting in El Paso to set up a Committee to work with amateurs in the field of paleontology. Objectives of this Committee were discussed at the 1950 meeting of the Council at Washington, D. C.

Members of the Committee are:

ARTHUR L. BOWSHER, U. S. National Museum, Washington, D. C., *Chairman*.
LEWIS M. CLINE, Department of Geology, University of Wisconsin, Madison, Wisconsin.
EDWARD HEUER, Department of Geology, University of Tulsa, Tulsa, Oklahoma.
LLOYD A. NELSON, Texas Western College, El Paso, Texas.
JOHN W. PRICE, 224 N. Pine St., Lancaster Pennsylvania.

The Committee will assist the American Geological Institute in compiling a list of amateur societies in North America and will study the possibility of publishing articles designed to acquaint the amateur with the latest methods and techniques of collecting, documenting and preserving fossils. Special attention will be given to the problems of clarifying for the amateur the basic value of fossils to science. It is hoped that the work of this committee will bring about closer co-ordination between amateur and professional paleontologists which in turn will be of great benefit to science.

MEETING PLANS for the INTERNATIONAL PALEONTOLOGICAL UNION in connection with the 1952 meetings of the International Geologic Congress

The Secretary of the Paleontological Society recently received the following data from Dr. H. Termier, President of the International Paleontologic Union, concerning plans being made for the scientific sessions to be held in Algiers during the International Geological Congress in 1952.

The Organization Committee, comprised of Dr. Termier, Mme. Termier, and Drs. Balout, Bernard, Guinochet, Hollande, Muraour and Ozenda, met on the 5th of May of this year and from suggestions sent in by paleontologists of various countries adopted the following list of four subjects about which half day programs each will be developed:

I. *Questions of methods and organization*
   a. *Correlation between the systematics of living and fossil organisms.*
      (Is it possible to achieve the same kind of determination made by biologists on the basis of hard-parts alone?)
   b. *Teaching of paleontology.*
      (The necessity of incorporating in this instruction the facts of biology.)
   c. *The necessity of abstracting and coordinating the paleontological work of various countries.*
   d. *Constitution of an international paleontological glossary.*

II. *Biostratigraphy and paleoecology*
(Authors are invited to give their presentations both a synthetic character and an aspect of general application.)
III. *Precambrian fossils*
(It is suggested that authors bring with them any examples in order that there may be an exposition of such material in the Geology Laboratory of the Faculty of Sciences in Algiers.)
IV. *Modalities of evolution, notably among invertebrates and plants*
(It is suggested that the paleobotanists pay particular attention to the origin of terrestrial floras on one hand and the origin of the angiosperms on the other.)

The Committee again expresses the hope that authors will not lose sight of the desirability of succinctness (caractère synthetique) in the presentation of papers in sections II and IV.

The Committee expressed the hope that a catalogue of Algerian type (guide) fossils be undertaken and be added to the Congress Guide Books.

Msr. Balout informed the Committee that he is in process of bringing together at the Musée du Bardo data pertaining to North African pre-history. It would be desirable that a general exposition of Fossil Man in North Africa be organized for presentation to the members of the Congress.

Dr. Termier's address is: Prof. Dr. Henri Termier, Laboratoire de Géologie, Université d'Alger, Alger, Algérie.

ANNUAL FALL MEETING OF PACIFIC COAST SECTION

The Pacific Coast Section, Society of Exploration Geophysicists, will hold its annual fall meeting on November 1 and 2 at the Ambassador Hotel in Los Angeles, it was announced by Robert Dyk, of General Petroleum Corp., Bakersfield, president of the section. The meeting will again be held in conjunction with the annual sessions of the local AAPG and SEPM groups and coordinated programs will be presented. Flint Agee, of United Geophysical Co., Pasadena, and vice president of the southern division of the Pacific Coast Section, will be in charge of program and arrangements for the SEG.

More than 200 exploration scientists on the West Coast are members of the Pacific Coast Section. Officers of the society are: Robert Dyk, president; John Sloat, Union Oil Co. of California, Bakersfield, vice president, Northern District; Flint Agee, vice president, Southern District; O. K. Fuller, Jr., Humble Oil & Refining Co., Los Angeles, Secretary-Treasurer; John D. Hale, Seaboard Oil Co., Bakersfield, district representative to the SEG; and V. E. Prestine, Western Geophysical Co., Los Angeles, district representative to the SEG.

EASTERN REGIONAL MEETING

An eastern regional meeting of the Society of Exploration Geophysicists will be held in Pittsburgh, Pa., on October 25, 1951, it was announced by Sigmund Hammer, of Gulf Research & Development Co., president of the society. Hammer has appointed Ralph B. Ross, also of Gulf Research, as general chairman of program and arrangements for the meeting. Ross, who is chairman of the eastern regional program committee for the SEG, will be assisted by Frank Press, of Columbia University and Bruno Winkler, of Standard Vacuum Oil Co., New York City. L. F. Melchior, D. A. Davis and W. B. Robinson, all of Gulf Research, are in charge of Local Arrangements.

In a joint announcement Ross said that registration and headquarters for the convention will be at the Webster Hall Hotel in Pittsburgh, and a full day of technical sessions will be conducted in the Mellon Institute Auditorium. Papers will be of general, rather than local, interest, with an evening lecture by a leading geologist sponsored by the Pittsburgh

Geological Society. Delegates to the meeting will be invited to tour the Mellon Institute of Industrial Research as well as the Gulf Research & Development Co. laboratories on the day following the technical sessions.

A number of volumes (no complete sets) of the Natural History of New York, and of the reports of the Wheeler, Hayden and King Surveys are available for distribution to anyone who will pay the packing and transportation charges. Preference will be given to libraries possessing broken sets of these publications. Anyone may send specific requests to editor Warthin at Vassar College, Poughkeepsie, N. Y.

JOURNAL OF PALEONTOLOGY, VOL. 25, NO. 5, PP. 709–712, SEPTEMBER 1951

STYLE, FORM AND PROCEDURE FOR THE JOURNAL OF PALEONTOLOGY

A. SCOTT WARTHIN, JR. AND J. MARVIN WELLER
Vassar College and University of Chicago

INTRODUCTION

THE editors try to get as much worthwhile paleontological literature published as rapidly, cheaply and accurately as possible. Adherence to certain forms and procedures will be of real help to both editors and printers.

It is not our purpose to furnish literary strait-jackets for authors. We believe that it is perfectly proper for an author to flavor his article with a personal literary style, as long as his writings are understood by his colleagues. The editors for the two societies are not now (and doubtless never will be, as editors come and go) in complete agreement on minutiae. We stand together in our primary aim, intelligibility.

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Use standard typewriter paper—8½ by 11 inch sheets. Do not use colored paper, lightweight or slippery stock.

Typewritten lines should not exceed 5½ or 6 inches in length, leaving a margin of about 1½ inches on each side of the page.

ALL typed material must be double spaced. This includes footnotes, quoted matter, bibliographies, synonymies etc. Manuscripts violating this rule will be returned at author's expense for retyping.

If a correction is to be made in the typed copy, write it in at the same level as the line in which it is to appear.

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Footnotes should be typed at the bottom of the manuscript page. Avoid them wherever possible, as they are expensive.

Leave the top third of the first page blank for instructions to the printer.

PARTS OF THE MANUSCRIPT

Title.—For the sake of future workers, keep the length of the title to the minimum necessary to avoid confusion. Type the title in capital letters.

Author.—Omit "By" before the author's name (which is also typed in capitals). A name at that point in the article can hardly be any but that of the author.

Address.—Give institution or company name, city, and if not implied in the preceding, the state. Omit "The" where it occurs as the first word of the name of the organization. If there is no business or institutional affiliation, give street, city and state.

Abstract.—Except for short notes, where the title in effect serves as the abstract, an abstract must be included. Make it informative. Do not write "The fauna of the Smith formation is described and its stratigraphic position discussed." Tell as briefly as possible what is in the fauna, and give the stratigraphic conclusions reached.

Table of contents.—This is necessary only under very exceptional circumstances.

Subdivision into headings.—Two types of headings generally are sufficient to subdivide and classify the parts of articles. They should be typed in the manuscript as:

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These should be centered in the page, and doubly underlined to indicate that they should be set in small capitals. Material falling under one center heading may be subdivided by:

Side headings.—These should be indented for paragraphing, underlined once for italics. and followed by a period and dash. Except for proper names, only the first letter of the initial word is capitalized in side headings. If a name of a genus or species is part of the side heading it is not italicized.

If further subdivision is necessary other types of centered headings may be used—

large capitals, large and small capitals or italics. Differentiation is indicated by triple underlining for large capitals, double for small and single underlining for italics.

Synonymies.—Consult recent issues of the JOURNAL or the United States Geological Survey's "Suggestions to authors" for acceptable forms. Stick to one form throughout an article.

Author's names.—Author's names following the names of genera or species in center headings above descriptions are printed in capital initials and lower case. In synonymies they are printed in large and small capitals. In the text they are lower case with capital initials—never in capitals as in many European publications.

Scientific names.—Names of genera and species are italicized, and should be so indicated by underlining except, (1) in headings above species descriptions, where they are set in Roman capitals, and (2) in italic headings where they are in Roman type for contrast.

Tiresome repetition of the generic name, when associated with one or more species in a discussion, can be avoided by using only the initial of the generic name, but care must be exercised that confusion is not introduced.

Descriptions.—Descriptions can be written in full "literary" style or variously shortened to the ultimate "telegraphese" where articles and unessential verb forms are omitted; connectives indicated by punctuation. Select whatever style seems most appropriate and adhere to it consistently.

It is an excellent plan to set up an outline for descriptions and adhere to it. This insures against the omission of necessary information and makes quick and accurate comparison possible for the reader.

Do not quote another author's description without a particular purpose. An old description adds nothing and is no substitute for the recording of new observations.

It is desirable to record the number of specimens examined, and descriptions should indicate the range of variation.

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A brief description of the lithology of the rock from which fossils are obtained is often important.

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Bibliographies.—Partial bibliographies, placed at the ends of articles under the small capital, centered heading "References," consist of the full titles and references abbreviated as indicated in the U. S. Geological Survey's "Suggestions to authors." Volume numbers should be indicated by Arabic rather than Roman numerals. Do not give the issue or part number of a periodical or any other work consisting of parts combined into volumes unless the parts are paged separately, or the publication date of the part is needed to establish nomenclatural priority.

Bibliographies ordinarily should not include unpublished works, or works to which reference is not made in the text.

Bibliographies should be arranged alphabetically by authors and chronologically under each author; where there is a coauthor, the references follow those of the senior author. A dash replaces the author's name on his second and succeeding works listed.

References.—References to the bibliography are made in the text by enclosing the author's name, date and page within parentheses (Smith, 1938, p. 476). Reference to personal communications can be made similarly (personal communication, A. H. Smith, Nov. 15, 1950).

Legibility.—Do not type with an old, faded ribbon. It lowers the accuracy and speed of both editor and printer. Use a nearly new ribbon; a completely new ribbon tends to smudge. Never submit carbon copies.

Intelligibility.—Read the manuscript slowly aloud to someone only moderately familiar with its content, and ask for strong constructive criticism.

Illustrations.—Illustrations are reproduced in three ways, by full-tone (collotype) inserted plates, by half-tones printed on the regular sheet, and by zinc (line) cuts. Consult Ridgway's "Scientific illustration" for information on usefulness and limitations of the three processes. A full-tone plate costs more than three times as much as a

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Alterations of proof sheets must be held to an absolute minimum as changes are costly. The editors assume that manuscripts submitted to them are in final form and correct in every detail. If an author desires to change his original copy he must be prepared to pay for it. The only possible exceptions are changes made necessary by new information obtained after the manuscript has gone to press. Changes will be made, however, at the author's request at any time prior to the press deadline.

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REFERENCES

RIDGWAY, J. L., 1938, Scientific illustration. Pp. i–xiv, 1–173, Stanford University Press, Stanford University, California.

WOOD, G. L., 1935, Suggestions to authors of papers submitted for publication by the United States Geological Survey, with directions to typists. 4th ed., revised and enlarged by B. H. Lane. Pp. i–vii, 1–126. Government Printing Office, Washington, D. C.

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